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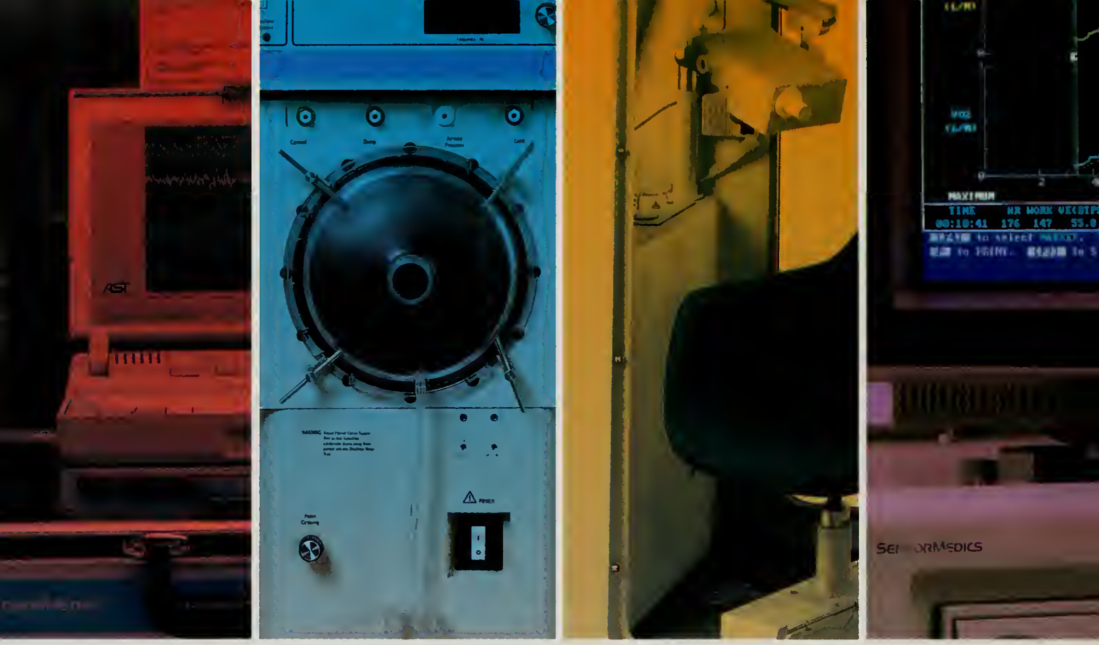

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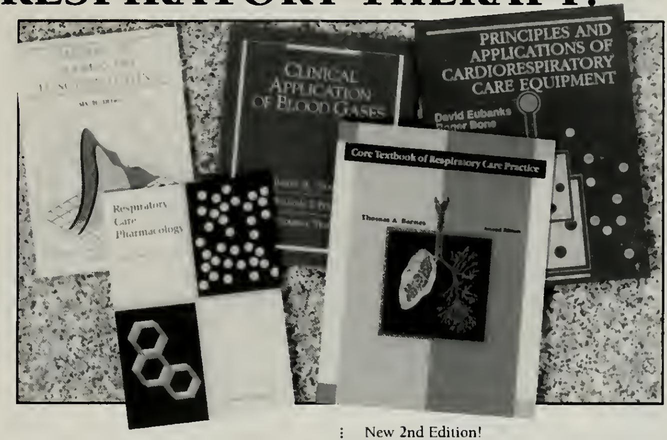
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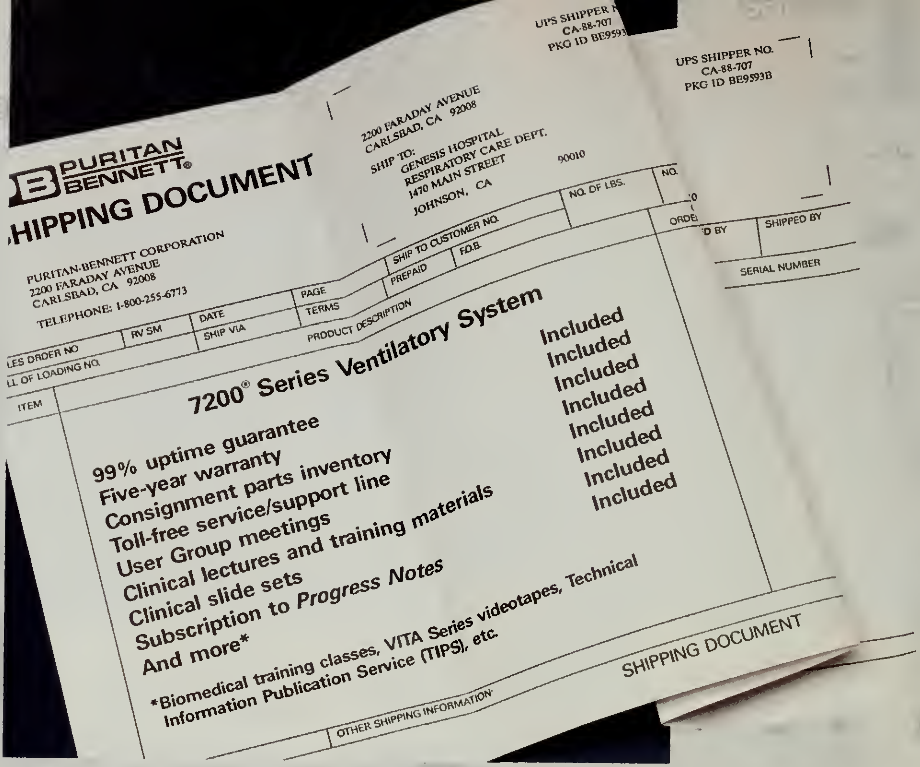

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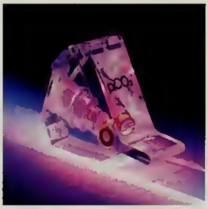

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Three Cases of Paradoxical Vocal Cord Adduction Followed Up Over a 10-Year Period (case report)—JP Hayes, MT Nolan, N Brennan, MX FitzGerald. Chest 1993;104:678.

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Methaemoglobin during Nitric Oxide Therapy with High-Frequency Ventilation (editorial)—JP Kinsella, SH Abman. Lancet 1993;342:615.

Pneumocystis carinii Pneumonia in Patients without Predisposing Illnesses: Acute Episode and Follow-Up of Five Cases—S Cano, F Capote, A Pereira, E Calderon, J Castillo. Chest 1993;104:376.

Pneumocystis carinii pneumonia (PCP) is described almost exclusively in immunocompromised hosts. This report describes our experience with acute episodes and the follow-up of five patients with PCP who had no known predisposing conditions. The average follow-up period was 3.6 years (range, 2.6 to 4 years). Lymphocyte subpopulations (CD4, CD8, and CD4:CD8), serum immunoglobulins (IgG, IgM, and IgA), and serologic studies for human immunodeficiency virus were carried out on all patients at least twice, both at the beginning and the end of the follow-up. None of the patients presented compatible data with AIDS or any other identifiable risk factors. We conclude that PCP can occur in patients who apparently do not have immunosuppression.

The CRIB (Clinical Risk Index for Babies) Score: A Tool for Assessing Initial Neonatal Risk and Comparing Performance of Neonatal Intensive Care Units—The International Neonatal Network. Lancet 1993;342:193.

Assessment of different hospitals' performance in neonatal intensive care has tended to rely on risk of mortality adjusted only for birthweight. We have developed a neonatal scoring system, CRIB (clinical risk index for babies), to take account of other factors. Scores are given for birthweight, gestational age, maximum and minimum fraction of inspired oxygen and maximum base excess during the first 12 h, and presence of congenital malformations. CRIB was developed retrospectively in a cohort of 812 infants of birthweight 1500 g or less or gestational age less than 31 weeks treated in four UK tertiary hospitals between 1988 and 1990. The scoring system was then validated by comparing its value as a predictor of hospital death with that of birthweight in a separate cohort of 488 similar infants. The area under the receiver operating characteristic (ROC) curve for predicting death in this validation cohort (a measure of the predictor's accuracy) was significantly greater for CRIB than for birthweight alone (0.90 [SE 0.051 vs 0.78 [0.03], p = 0.04). Both indices of initial risk were used to assess the performance of nine tertiary and four non-tertiary hospitals in the UK. We looked at hospital mortality among the 1300 infants in the development and validation cohorts plus 248 other infants of birthweight 1500 g or less or gestational age less than 31 weeks. Without adjustment for initial risk, there was no clear difference in group mortality between the tertiary and non-tertiary hospitals. However, calculation of risk-adjusted mortality by means of CRIB showed that babies were twice as likely to die in the non-tertiary hospitals as in the tertiary hospitals (odds ratio 2.12 [95% CI 1.39-3.24]). Adjustment for birthweight alone also showed higher

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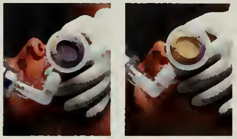

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Nedocromil Sodium Is More Effective Than Cromolyn Sodium for the Treatment of Chronic Reversible Obstructive Airway Disease—S Lal, PD Dorow, KK Venho, SS Chatterjee. Chest 1993;104:438.

In a multicenter, double-blind, group comparative trial, the efficacy of nedocromil sodium (nedocromil, 4 mg, four times daily [qid]), cromolyn sodium (2 mg, qid), and placebo was compared in patients receiving inhaled β_2-agonists and inhaled corticosteroids for the treatment of chronic, reversible, obstructive-airway disease. After a 2-week baseline period, 132 patients (8 centers) between the ages of 20 and 75 years entered a 4-week run-in period in which the dose of inhaled corticosteroid was reduced by 50%. During the run-in phase, deterioration of symptoms (total symptom score) by ten points qualified patients to enter the 6-week drug trial period. Patients in the nedocromil treatment group showed the most robust and consistent improvements over placebo and cromolyn sodium for all daily diary variables. Statistically significant improvements over placebo were noted for both active treatment groups for daytime, nighttime, and total symptom score. Symptom scores for nedocromil were statistically significantly improved over both cromolyn sodium and placebo for both daytime and nighttime asthma. Patients treated with nedocromil also demonstrated a significant reduction in the use of nighttime as needed (prn) β_2-agonists as compared with either the placebo- or cromolyn sodium-treated groups. Only nedocromil-treated patients demonstrated a statistically significant improvement in morning peak expiratory flow rate (PEFR) as compared with placebo. Both nedocromil and cromolyn sodium groups demonstrated statistically significant improvements in afternoon and evening PEFRs. Collectively, the improvements in nighttime symptoms, decreased bronchodilator use, and improved morning PEFR show that patients treated with nedocromil had improved nocturnal symptoms. Pulmonary function tests (FEV_1, FVC, PEFR) demonstrated no statistically significant differences between the two active treatments, although trends favored nedocromil for both FEV_1 and PEFR. Although symptoms improved in patients treated with cromolyn sodium, the level of symptom control was less than that achieved by nedocromil. As compared with baseline control (regular dose of inhaled steroids), patients treated with nedocromil plus the 50% reduced dosage of inhaled corticosteroid consistently demonstrated comparable or better symptom control. Although both active drugs reduced symptoms, nedocromil proved to be more effective than cromolyn sodium for treatment of reversible obstructive airway disease in patients normally well maintained on regimens of low to moderate doses of inhaled corticosteroids.

Comparative Evaluation of Three Heat and Moisture Exchangers During Short-Term Postoperative Mechanical Ventilation—T Sottiaux, G Mignolet, P Damas, M Lamy. Chest 1993;104:220.

This study compared performance of three heat and moisture exchangers (HME) during short-term postoperative mechanical ventilation. Temperature (T°) and absolute humidity (AH) were measured at various points of the ventilatory circuit. There was no statistical difference between the groups, regarding ambient and body T°, body weight, fraction of inspired oxygen, tidal volume, and respiratory rate. Only the hygroscopic HME (Groups 2 and 3) provide adequate conditioning with regard to AH and T° of the inspiratory gases. The performance of

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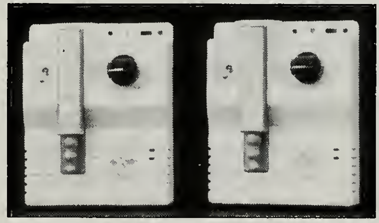

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WARNINGS: As with other inhaled beta-adrenergic agonists, Albuterol Sulfate Inhalation Solution can produce paradoxical bronchospasm, which can be life threatening If it occurs, the preparation should be discontinued immediately and alternative therapy instituted

Fatalities have been reported in association with excessive use of inhaled sympathomimetic drugs and with the home use of nebulizers It is, therefore, essential that the physician instruct the patient in the need for further evaluation if his/her asthma becomes worse In individual patients, any beta$_2$-adrenergic agonist, including albuterol solution for inhalation, may have a clinically significant cardiac effect

Immediate hypersensitivity reactions may occur after administration of albuterol as demonstrated by rare cases of urticaria, angioedema, rash, bronchospasm, and oropharyngeal edema

PRECAUTIONS General: Albuterol, as with all sympathomimetic amines, should be used with caution in patients with cardiovascular disorders, especially coronary insufficiency, cardiac arrhythmias and hypertension, in patients with convulsive disorders, hyperthyroidism or diabetes mellitus, and in patients who are unusually responsive to sympathomimetic amines

Large doses of intravenous albuterol have been reported to aggravate pre-existing diabetes mellitus and ketoacidosis

As with other beta-agonists, inhaled and intravenous albuterol may produce a significant hypokalemia in some patients, possibly through intracellular shunting, which has the potential to produce adverse cardiovas-cular effects The decrease is usually transient, not requiring supplementation.

Information for Patients: The action of Albuterol Sulfate Inhalation Solution may last up to six hours and therefore it should not be used more frequently than recommended Do not increase the dose or frequency of medication without medical consultation If symptoms get worse, medical consultation should be sought promptly While taking Albuterol Sulfate Inhalation Solution, other anti-asthma medicines should not be used unless prescribed

Drug Interactions: Other sympathomimetic aerosol bronchodilators or epinephrine should not be used concomitantly with albuterol

Albuterol should be administered with extreme caution to patients being treated with monoamine oxidase inhibitors or tricyclic antidepressants, since the action of albuterol on the vascular system may be potentiated

Beta-receptor blocking agents and albuterol inhibit the effect of each other

Carcinogenesis, Mutagenesis and Impairment of Fertility: Albuterol sulfate, like other agents in its class, caused a significant dose-related increase in the incidence of benign leiomyomas of the mesovarium in a 2-year study in the rat, at oral doses corresponding to 10, 50 and 250 times the maximum human nebulizer dose In another study, this effect was blocked by the coadministration of propranolol The relevance of these findings to humans is not known An 18-month study in mice and a lifetime study in hamsters revealed no evidence of tumorigenicity Studies with albuterol revealed no evidence of mutagenesis Reproduction studies in rats revealed no evidence of impaired fertility

Pregnancy: Teratogenic Effects: Pregnancy Category C: Albuterol has been shown to be teratogenic in mice when given subcutaneously in doses corresponding to the human nebulization dose There are no adequate and well-controlled studies in pregnant women Albuterol should be used during pregnancy only if the potential benefit justifies the potential risk to the fetus A reproduction study in CD-1 mice with albuterol (0 025, 0 25 and 2 5 mg/kg subcutaneously, corresponding to 0 1, 1, and 12 5 times the maximum human nebulization dose, respectively) showed cleft palate formation in 5 of 111 (4 5%) of fetuses at 0 25 mg/kg and in 10 of 108 (9 3%) of fetuses at 2 5 mg/kg None were observed at 0 025 mg/kg Cleft palate also occurred in 22 of 72 (30.5%) of fetuses treated with 2 5 mg/kg isoproterenol (positive control). A reproduction study in Stride Dutch rabbits revealed cranioschisis in 7 of 19 (37%) of fetuses at 50 mg/kg, corresponding to 250 times the maximum human nebulization dose

Labor and Delivery: Oral albuterol has been shown to delay preterm labor in some reports There are presently no well controlled studies which demonstrate that it will stop preterm labor at term Therefore, cautious use of Albuterol Sulfate Inhalation Solution is required in pregnant patients when given for relief of bronchospasm so as to avoid interference with uterine contractibility

Nursing Mothers: It is not known whether this drug is excreted in human milk. Because of the potential for tumorigenicity shown for albuterol in some animal studies, a decision should be made whether to discontinue nursing or to discontinue the drug, taking into accord the importance of the drug to the mother

Pediatric Use: Safety and effectiveness of albuterol solution for inhalation in children below the age of 12 years have not been established

ADVERSE REACTIONS: The results of clinical trials with Albuterol Sulfate Inhalation Solution in 135 patients showed the following side effects which were considered probably or possibly drug related

Central Nervous System: tremors (20%), dizziness (7%), nervousness (4%), headache (3%), insomnia (1%)
Gastrointestinal: nausea (4%), dyspepsia (1%)
Ear, Nose and Throat: pharyngitis (<1%), nasal congestion (1%).
Cardiovascular: tachycardia (1%), hypertension (1%)
Respiratory: bronchospasm (8%), cough (4%), bronchitis (4%), wheezing (1%)

No clinically relevant laboratory abnormalities related to Albuterol Sulfate Inhalation Solution administration were determined in these studies

In comparing the adverse reactions reported for patients treated with Albuterol Sulfate Inhalation Solution with those of patients treated with isoproterenol during clinical trials of three months, the following moderate to severe reactions as judged by the investigators, were reported This table does not include mild reactions

Percent Incidence of Moderate to Severe Adverse Reactions

Reaction	***Albuterol*** **N=65**	***Isoproterenol*** **N=65**		***Albuterol*** **N=65**	***Isoproterenol*** **N=65**
Central Nervous System					
Tremor	10 7%	13 8%	Headache	3 1%	1 5%
Insomnia	3 1%	1 5%			
Cardiovascular					
Hypertension	3 1%	3 1%	Arrhythmias	0%	3%
**Palpitation	0%	22%			
Respiratory					
*Bronchospasm	15 4%	18%	Cough	3 1%	5%
Bronchitis	1 5%	5%	Wheeze	1 5%	1 5%
Sputum Increase	1 5%	1 5%	Dyspnea	1 5%	1 5%
Gastrointestinal					
Nausea	3 1%	0%	Dyspepsia	1 5%	0%
Systemic					
Malaise	1 5%	0%			

** In most cases of bronchospasm, this term was generally used to describe exacerbations in the underlying pulmonary disease*

*** The finding of no arrhythmias and no palpitations after albuterol administration in this clinical study should not be interpreted as indicating that these adverse effects can not occur after the administration of inhaled albuterol*

Rare cases of urticaria, angioedema, rash, bronchospasm and oropharyngeal edema have been reported after the use of inhaled albuterol

OVERDOSAGE: Manifestations of overdosage may include seizures, anginal pain, hypertension, hypokalemia, tachycardia with rates of up to 200 beats per minute, and exaggeration of the pharmacological effects listed in **ADVERSE REACTIONS.** The oral LD$_{50}$ in rats and mice was greater than 2,000 mg/kg The inhalational LD$_{50}$ could not be determined There is insufficient evidence to determine if dialysis is beneficial for overdosage of albuterol

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hydrophobic HME (Group 1) was inferior and appears to be unsatisfactory. Indirect evaluation (variations of inspiratory gases and tracheal temperatures, AH of the expired gases) confirmed the superiority of the hygroscopic HME. These data suggest that humidification of inspiratory gases with a hygroscopic HME is a defensible practice during short-term postoperative mechanical ventilation. Performance of hydrophobic HME may be weak and can expose the patient to an unacceptable risk of endotracheal tube occlusion.

Effects of Oxygen on Dyspnoea in Hypoxaemic Terminal-Cancer Patients—E Bruera, N de Stoutz, A Velasco-Leiva, T Schoeller, J Hanson. Lancet 1993;342:13.

Dyspnoea is a frequent and devastating symptom of advanced cancer. The purpose of this prospective, double-blind, crossover trial was to assess the effects of supplemental oxygen on the intensity of dyspnoea. 14 patients with hypoxaemic dyspnoea due to advanced cancer were randomised to receive either oxygen or air; the gases were delivered at 5 L/min by mask. After 5 min of stable oxygen saturation (pulse oximetry), patients were crossed over to receive the other treatment. The crossover was repeated twice. Dyspnoea was assessed with a visual analogue scale (0 = no dyspnoea, 100 = worst dyspnoea). Mean difference in dyspnoea visual analogue scale between air and oxygen treatment was 20.5 (95% confidence interval 13.5 to 27.6). 12 patients consistently preferred oxygen to air; similarly, the investigator consistently chose oxygen for the same 12 patients. In a global rating questionnaire, patients reported little or no benefit during the air phase compared with moderate to much benefit during the oxygen phase. We conclude that oxygen is beneficial to patients with hypoxia and dyspnoea at rest.

Semi-Automatic Analysis of Electroencephalogram in Sleep Apnea Syndromes—FF Philip-Joet, MF Rey, AA DiCroco, MJ Reynaud-Gaubert, AG Arnaud. Chest 1993; 104:336.

STUDY OBJECTIVE: The present study was undertaken to validate a system of condensed display of the sleep EEG spectral analysis with a view to simplifying sleep studies in patients affected by sleep apnea syndromes (SAS). DESIGN: All subjects underwent polysomnography on two consecutive nights using a Respisomnograph. The 8-h EEG, electro-oculogram, and electromyogram were digitized. A fast Fourier transform was done and successive spectrums were computed, resulting in one spectrum for each 20-s period. Then the EEG spectrum was plotted as a Lofard color diagram. SETTING: To validate this system we compared a visual analysis of EEG recordings by a trained neurophysiologist with 10-s epochs and a visual analysis of the Lofard diagram by a practitioner with no previous understanding in EEG after only 2 h of instruction. The 8-h recording was divided into 10-min blocks. Each block was staged in function of the amplitude and prevailing frequency of EEG as indicated by the color (wakefulness, light-slow-wave sleep, deep-slow-wave sleep, rapid eye movement sleep). The stage of each block was compared with the predominant stage found in this block by the neurophysiologist. PATIENTS: 8 normal adults and 24 patients suffering from SAS were recruited. RESULTS: When all the blocks of all patients were pooled (1,438 blocks), agreement was total in 81%, partial in 11%, and discordant in 8%. CONCLUSION: This system of spectral analysis representation allows a fast evaluation of quality of sleep and of EEG.

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Aerosol Consensus Statement, Respiratory Care, Sept.'91, Vol. 36 No. 9

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lso eliminate the need to
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nd inhalation.”
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espiratory Care, Sept.’91,
ol. 36 No. 9

“This study has demonstrated that a MDI plus aerosol holding chamber delivers a nearly fivefold greater dose of aerosolized drug to the lungs in comparison with a jet nebulizer in patients receiving mechanical ventilation.”
H.D. Fuller, M.B. Dolovich, G. Posmituck, W. Wong Pack, and M.T. Newhouse. Pressurized Aerosol versus Jet Aerosol Delivery to Mechanically Ventilated Patients. Am Rev Respir Dis 1990; 141:440-444.

“The Aerochamber and MDI appears to be a highly efficient method of budesonide delivery to ventilated infants.”
J. Grigg, et al Hammersmith Hospital, London, England. Delivery of therapeutic aerosols to intubated babies. Archives of Disease in Childhood 1992; 67: 25-30

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Clean 'Em or Toss 'Em—Does It Matter?

This issue of the Journal contains the report of a study of the prevalence of bacterial contamination with reusable pulse oximeter probes.[1] In his paper, the author reports that 66% of probes cultured were contaminated with bacteria. The probes tested were acquired from a variety of institutions, some of which reported cleaning their probes between patients, and some of which did not. All were deemed by their respective facilities to be "ready" for use on patients. From these findings the author suggests that (1) reusable pulse oximetry sensors could serve as a vehicle for pathogens causing nosocomial infections and (2) clinicians ought to use only "the patient-dedicated sensors ... when "... infection control is of particular concern ...." This study raises a number of questions regarding the transmission of infections among hospitalized patients.

Although this report did not give much detail on how the probes were acquired, they appear to have been solicited from a number of hospitals. But how were they handled and shipped from these facilities? Were they aseptically packaged and handled? If not, then it is possible that they were contaminated en route. If this is true, the method by which they were cleaned (if they were cleaned) is not particularly important, because unprotected handling could have been the cause of contamination. We can't tell for sure!

But, assuming that the author's findings accurately reflect the routine condition of 'patient-ready' reusable pulse oximeter probes, the more important question is, "Does it really matter whether a noninvasive device applied to intact skin harbors organisms?" The Centers for Disease Control and Prevention has stated that items used noninvasively and touching only intact skin rarely, if ever, transmit disease.[2] Should we assume that because such organisms are present on pulse oximeter probes remedial action is required? Not even the experts know for sure!

In this current work, an interesting study is cited. Sokalski et al describe an outbreak of nosocomial infections involving *Serratia marcescens* that the authors contend was linked to the reuse of 12-lead electrocardiogram (ECG) bulbs.[3] Fourteen postoperative infections were traced (through some thorough detective work) to the reusable Welsh bulbs of 7 ECG machines that were found to be contaminated with *S marcescens*. However, it is very interesting to note that all the patients who got these infections had their ECGs done in the operating room immediately following wound closure and dressing application, while there was still blood and serum on the patient's skin. When the suction cups were applied in the presence of this blood, "bruising and oozing of serum from the skin" resulted. These same contaminated ECG bulbs were used throughout the hospital, but laboratory and infection control records provided no evidence of new *S marcescens* infections elsewhere. Thus, the development of nosocomial infections was facilitated by a fomite only under unusual circumstances (ie, applying suction cups to the skin of patients in such a fashion that the integrity of the cutaneous barrier was violated).

Another study[4] cited by the author reported longitudinal surveillance of nosocomial infections in a neonatal intensive care unit that led the investigator to conclude that a single blood-pressure cuff that had been used on all infants was, in fact, a vehicle for pathogenic organisms and was responsible for a considerable portion of the infections in that unit. When this cuff was replaced by patient-dedicated cuffs, reportedly there was a decrease in the incidence of nosocomial infections. However, at about the same time, a variety of other infection control practices were introduced or modified, including (1) the installation of additional hand-washing sinks, (2) severe restriction of foot-traffic within the unit, (3) increased infection-control instruction for all caregivers, (4) use of disposable medication nebulizers, and (5) increased frequency of linen and equipment changes. Thus, it is impossible to conclude from these findings that this blood pressure cuff was the culprit. But, for the sake of argument, let's assume that it was. Like the Welsh ECG bulbs in the report cited earlier, the blood-pressure cuff is used so that it applies considerable physical force to the skin, and might well have caused a violation of skin integrity; this is especially likely in neonates whose skin is notoriously fragile.

Considering these findings and those reported in this issue of the Journal, it is not yet prudent to draw broad conclusions about the need for rigorous, standardized cleaning methods for noninvasive devices that are applied only to intact skin. In most populations, it probably doesn't matter whether these probes harbor pathogenic microorganisms. But, we don't know that for sure!

The use of patient-dedicated, aseptic probes in certain patients with increased susceptibility to infections is certainly a more tenable argument. The author suggests that disposable probes may be most appropriate in such patients. This is a costly alternative; however, disposable probes may be effectively recycled and the costs reduced.[5]

The author has done us a service by performing this interesting study and, like most research, it answers one question—only to give rise to many others. And, for now, we still don't know for sure.

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Physician-Ordered Respiratory Care vs Physician-Ordered Use of a Respiratory Therapy Consult Service: Early Experience at The Cleveland Clinic Foundation

James K Stoller MD, David Haney RRT, John Burkhart RRT,
Larry Fergus RN MBA RRT, Dennis Giles RRT, Ed Hoisington RRT,
Lucy Kester MBA RRT, John Komara RRT, Kevin McCarthy RCPT,
Ben McCann RRT, Rebecca Meredith RRT, Doug Orens MBA RRT,
and the Section of Respiratory Therapy

BACKGROUND: Accumulating evidence suggests that respiratory care is frequently misallocated. We report the results of a pilot study of a delivery system aimed at correcting such misallocation. METHODS: The delivery system (Respiratory Therapy Consult Service, or RTCS) allows respiratory therapists (when requested by the case-managing physician) to determine respiratory care, with decisions guided by algorithm (ie, Consult patients). In the pilot study, Therapist Evaluators responded to requests for Consults on two study wards. All staff therapists participated in implementing Evaluator-determined treatment. STUDY DESIGN: We evaluated 38 patients (20 of whom were Consult patients) randomly selected from a total of 82 patients undergoing abdominal surgery during the study period. RESULTS: Consult patients were significantly older than non-Consult patients, more likely to be heavy smokers (67 vs 43%), and sicker as suggested by a higher Triage Score. Consult patients received more types and more total respiratory care services, demonstrated a trend toward longer stay, and had significantly higher respiratory therapy charges. CONCLUSION: Our experience shows that a consult program can be successfully implemented in a large, tertiary care institution with widespread physician and nursing support. Whether the RTCS fulfills its goal of ameliorating misallocation of respiratory care has yet to be proven and awaits the completion of other studies currently under way.
[Respir Care 1993;38(11):1143-1154.]

Dr Stoller is Head, Section of Respiratory Therapy, and Staff Physician, Pulmonary and Critical Care Medicine; Mr Haney and Ms Meredith are Respiratory Therapists, Section of Respiratory Therapy; Messrs Burkhart, Giles, Hoisington, Komara, and McCann are Supervisors/Workleaders, Section of Respiratory Therapy; Mr Fergus is Administrator, Department of Pulmonary Medicine and Section of Respiratory Therapy; Mr McCarthy is Supervisor, Pulmonary Function Laboratory; and Mr Orens is Manager, Section of Respiratory Therapy—The Cleveland Clinic Foundation, Cleveland, Ohio.

A version of this paper will be presented by Mr Haney during the Respiratory Care Open Forum at the 1993 AARC Annual Meeting to be held in Nashville, Tennessee, December 11-14, 1993.

Reprints: James K Stoller MD, Department of Pulmonary and Critical Care Medicine, Section of Respiratory Therapy, The Cleveland Clinic Foundation, 9500 Euclid Ave, Cleveland OH 44195.

Introduction

Increasing evidence suggests that respiratory care is often misallocated in current practice (ie, care is ordered when it is not needed and is not ordered when it might be helpful).[1-4] At the Cleveland Clinic Foundation, a recent retrospective audit of 230 adult non-ICU inpatients for whom some respiratory care was ordered showed that 25.2% of patients received some respiratory care deemed inappropriate and that 11.2% of patients might have benefitted from a respiratory treatment that was not ordered. Because misalignment of service demands and needs can threaten the goals of providing proficient and efficient care, several solutions have been proposed, including authoritative control of respiratory care delivery[5] (sometimes with major cutbacks in respiratory care services),[6] and allocation of decision making about patients' respiratory care needs to respiratory therapists using structured criteria, a strategy that has been called therapist-driven or evaluate-and-treat protocols.[7-10]

The purpose of the current report is to describe our early experience at the Cleveland Clinic Foundation with a new delivery strategy that allows respiratory care practitioners to allocate care using sign- and symptom-based algorithms for respiratory treatment.[7] By analogy with other health care services in which decisions about the type and amount of care are delegated to practitioners (eg, occupational and physical therapy consultations), we have called this new strategy the Respiratory Therapy Consult Service (RTCS).

In the context of an early pilot study of the RTCS, the specific goals of the current research are (1) to compare the types of patients for whom respiratory therapy consultation is ordered by the managing physician versus those managed by physicians themselves and (2) to compare total hospital and respiratory therapy charges and length of stay for these two groups.

Methods

Organization of the Respiratory Therapy Consult Service

A pilot study of the Respiratory Therapy Consult Service (RTCS) began on February 1, 1992, on two separate wards: one medical (Pulmonary and/or Infectious Diseases) and one surgical (Colorectal Surgery).

Key elements in organizing the Respiratory Therapy Consult Service include

(1) A team of Therapist Evaluators, comprised of senior and/or supervisory RRTs who have been involved in drafting the algorithms (Appendix 1), are familiar with their use, and respond to Consults on a same-shift basis. In response to an order by the managing physician for "Respiratory Therapy Consult," the Evaluators generate a written Respiratory Therapy Care Plan, which is placed in the progress notes of the medical record (Appendix 2). Simple indicated therapies, such as initiating oxygen, may be implemented by the Evaluators themselves.

(2) A team of Implementing Therapists to whom the written respiratory therapy care plan is communicated verbally and/or using a respiratory care management information system (CliniVision, Puritan-Bennett, Carlsbad CA). At the time of the current study, 10 individuals participated as Evaluators and all staff therapists participated as Implementors.

(3) A series of 9 symptom- and sign-based algorithms using branching logic diagrams to generate a recommended respiratory therapy treatment. As specified in Appendix 1, algorithms have been proposed for administering aerosol therapy (bland and with medications including bronchodilators, mucolytics, and vasoconstrictors), bronchopulmonary hygiene (eg, percussion, vibration, postural drainage), hyperinflation techniques (eg, incentive spirometry, intermittent positive pressure breathing, and positive expiratory pressure), and oxygen therapy. Prior to adoption, all algorithms were externally reviewed by several respiratory care authorities (personal communication, Robert M Kacmarek PhD RRT, Dean Hess EdD RRT, Colleen M Kigin MS MPA PT, 1993) for appropriateness and compliance with available Clinical Practice Guidelines published by the American Association for Respiratory Care.[11-14]

(4) A Triage Score, which had been developed for the RTCS, is used to assign priority for respiratory care treatments when demand for services exceeds available manpower (Appendix 3). The Triage Score sums ratings on 8 clinical features (smoking history, surgical history, chest x-ray, respiratory pattern, mental status, breath sounds, cough, and level of activity) to assign a score of maximum 32 points, with more points assigned for greater degrees of physiologic impairment. The 32-point rating is ordinalized into 5 Triage Score categories (Triage 1 to Triage 5), with Triage 1 representing the greatest degree of illness. As summarized in Appendix 3, initial Triage Scores also determined the frequency with which respiratory therapy was performed and the initial frequency with which patients' respiratory needs were re-evaluated by Evaluators (ie, from daily to every third day), although care plans could be adjusted using the algorithms on a shift-by-shift basis if clinically warranted.

The Respiratory Therapy Consult Service was available by physician discretion and was neither mandated nor allocated by randomization in the current study. Specifically, the current report compares respiratory care practices when physicians request respiratory therapy consultation (and delegate respiratory care management to the RTCS) vs when physicians decide to prescribe respiratory care themselves.

Orientation sessions for nurses and for both staff physicians and house officers on wards where the RTCS was available were provided by the Respiratory Therapy Education Coordinator (LK) and by Respiratory Therapy supervisory staff. Handbooks containing all of the algorithms, the triage scoring system, and a description of the RTCS with ordering information were provided to nurses and physicians on the study wards.

Design of the Current Study

For the current pilot study, we evaluated a randomly selected sample of 38 patients undergoing upper abdominal surgery between February 1, 1992 and March 31,1992. These 38 patients (20 with respiratory care determined by the RTCS [Consult] and 18 with respiratory care determined by their physicians without respiratory therapy consultation [Non-Consult]) were selected randomly from 82 total patients undergoing upper abdominal surgery in the study interval (31 Consult, 51 Non-Consult). Using a computerized respiratory care management information system for data retrieval, respiratory therapy records were reviewed for types and numbers of respiratory care services provided, total number of respiratory care services provided (by type), and numbers of new respiratory orders placed after the initial 24 hours of hospitalization. Data on length of hospital stay, total respiratory care charges, and total care charges were retrieved from the Office of Patient Finance. For the 18 Non-Consult patients studied, Triage Scores were recorded and assigned retrospectively, based on the patient's admission status.

A one-time charge of $39 was applied for the RTCS, which is included in the respiratory care charges calculated for Consult patients.

Results

Characteristics of the Consult and Non-Consult patients are presented in Table 1. Consult patients were older than Non-Consult patients (mean [SD] age 61 [17.3] years vs 45 [15.6] years, $p = 0.006$) and showed a nonsignificant trend toward a greater frequency of ex- or current smoking (63% vs 44%). More heavy smokers (> 1 pack/day) were Consult patients than Non-Consult patients (67% of current smokers vs 43%), although a statistically significant difference was not observed.

Table 2 contains individual patient data for the Consult and Non-Consult groups. As indicated by higher Triage Points (mean [SD] = 9.5 [2.9] vs 4.8 [1.0], $p < 0.001$) and lower Triage Score (ie, higher level of illness) in Consult patients (mean [SD] = 3.8 [0.64] vs 4.8 [0.43], $p < 0.001$), Consult patients were deemed to have more severe respiratory illness. Because patients in both groups were managed by the same team of colorectal surgeons and house staff, this observation suggests that physicians selected sicker patients for respiratory therapy consultation and chose to self-manage healthier patients.

Table 1. Characteristics of Consult and Non-Consult Patient Groups

Feature	Consult Patients (n = 20) Mean (SD) age, range 61 (17.3), 24-83*	Non-Consult Patients (n = 18) Mean (SD) age, range 45 (15.6), 27-73
% Female	50	44
Type of surgery (% of total)		
Colectomy	70	61
Ileostomy	10	28
Exploratory laparotomy	20	11
Smoking status (% of total)		
Current	45	39
Ex-smoker	15	6
Never smoker	30	50
Unknown	10	6
Mean FEV_1 % predicted (SD), range	1.21 (0.36), 0.70-1.89†	NA
Mean % pulse oximetry oxygen saturation (SD), range on room air	94.2 (4.0), 87-99‡	NA

*Difference between Consult and Non-Consult patients significant at $p < 0.05$.
†Based on 12 patients for whom data are available.
‡Based on 9 patients for whom room air pulse oximetry data are available.
NA = not available.

As shown in Table 2 and in Figure 1, Consult patients received significantly more types of respiratory care services than Non-Consult patients (mean [SD] = 3.4 [1.6] vs 2.2 [1.3] services, $p < 0.01$) and more total respiratory care activities per patient than Non-Consult patients (mean [SD] = 38.1 [27.2] vs 8.7 [6.0] activities/patient, p = 0.001). As an indicator of the degree of active readjustment of respiratory care in Consult patients, more new treatments were ordered per Consult patient after the first 24 hours of hospitalization than in Non-Consult patients (mean [SD] = 1.5 [1.5] vs 0.28 [0.67] treatments/patient, p = 0.02). Finally, Consult patients showed a nonsignificant trend toward longer hospital stay than Non-Consult patients (mean [SD] = 14.0 [11.7] vs 8.7 [4.0] days, p = 0.19) and had approximately 5-fold higher respiratory care charges than Non-Consult patients (mean [SD] = $1,728 [$1,586] vs $282 [$224], p = 0.001).

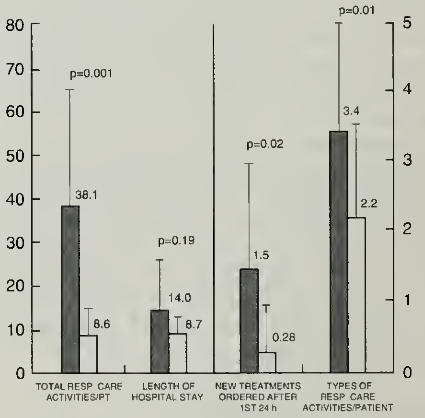

Fig. 1. Comparison of Consult and Non-Consult services and length of hospital stay. Left vertical scale applies to two sets of bars in left panel. ■ = Consult patients; □ = Non-Consult patients.

Table 2. Summary of Results for Consult vs Non-Consult Patients

Type of Care	Patient	Triage* Score	Triage† Points	Types of RC Service	Total RC Treatments	Changes in RC Orders (after 1st 24 h)	Length of Hospital Stay (days)	RC Charges ($)‡
Consult	1	2	15	4	35	3	9	2391
	2	4	8	3	12	3	9	387
	3	4	9	4	32	2	9	648
	4	4	10	2	18	1	7	648
	5	3	13	4	64	3	11	2640
	6	4	10	5	85	4	22	5663
	7	4	7	4	116	0	42	5231
	8	4	7	5	44	2	15	1597
	9	4	10	4	20	2	11	772
	10	5	5	1	7	0	6	414
	11	3	12	7	65	5	7	3509
	12	4	8	3	22	0	14	736
	13	4	10	3	41	1	9	1648
	14	4	6	1	19	0	9	589
	15	3	13	5	27	2	NA	NA
	16	4	9	4	51	1	11	2376
	17	4	8	2	25	0	5	582
	18	4	6	2	9	0	13	1351
	19	3	18	1	34	0	9	314
	20	4	9	4	36	0	48	1344
Mean (SD):		3.8 (0.64)	9.5 (2.9)	3.4 (1.6)	38.1 (27.2)	1.5 (1.5)	14.0 (11.7)	1728 (1586)
Non-Consult	1	4	6	1	5	0	14	172
	2	5	5	1	6	0	7	197
	3	5	5	3	10	0	7	344
	4	5	4	3	3	0	9	467
	5	5	5	1	21	1	4	NA
	6	4	6	3	10	0	10	417
	7	5	5	3	14	0	15	538
	8	4	6	1	3	0	15	72
	9	5	3	1	3	0	12	122
	10	4	7	6	25	2	6	937
	11	5	3	2	4	2	15	230
	12	5	5	1	5	0	6	172
	13	5	5	3	10	0	8	417
	14	5	5	1	5	0	7	172
	15	5	4	1	9	0	9	247
	16	5	4	3	8	0	2	NA
	17	5	4	3	9	0	4	344
	18	5	5	2	7	0	7	220
Mean (SD):		4.8 (0.64)	4.8 (2.9)	2.2 (1.3)	8.7 (6.0)	0.28 (0.67)	8.7 (4.0)	282 (224)
	p value§	< 0.001	< 0.001	0.01	0.001	0.02	0.19	0.001

*Triage Score range is 1 to 5, where 1 is assigned to highest acuteness or severity.

†Triage Points range 0 to 32, where 32 is assigned for the greatest physiologic and clinical derangement.

‡Includes a one-time Consult charge of $39.00.

§Consult vs Non-Consult.

NA = not available.

Examination of individual patient data in Table 2 shows that whereas the maximal length of stay among Non-Consult patients was 15 days (3 patients with mean 4.6 Triage Points stayed 15 days), 4 Consult patients had stays $\geq$ 15 days (mean length of stay 32 days among these 4 patients with mean 8.3 Triage Points). Excluding all 3 Consult patients whose length of stay exceeded 15 days narrows the difference in respiratory care charges between Consult and Non-Consult patients (mean $1,313 vs $282), although a 4.6-fold mean difference persists. Also, respiratory care charges per day of hospital stay were higher among Consult patients (mean [SD] $139.00 [$116.00] vs $41.00 [$37.00], $p < 0.001$), which is consistent with Consult patients' higher degree of respiratory illness.

To better assess respiratory care practices among matched Consult vs Non-Consult patients, a comparison between Consult and Non-Consult patients with similar Triage Scores was undertaken. Because mean Triage Scores were lower in Consult patients, significant overlap was confined to patients with Triage Score 4 (14 Non-Consult patients, 4 Consult patients). As shown in Table 3, Consult patients assigned Triage Score 4 incurred significantly greater total respiratory care charges (mean [SD] = $1,684 [$1,689] vs $400 [$378], $p = 0.038$), but showed no other statistically significant differences from Non-Consult patients.

Discussion

The results of this early assessment of the Cleveland Clinic Respiratory Therapy Consult Service suggest the following five conclusions:

- A Respiratory Therapy Consult Service (RTCS), or an evaluate-and-treat program, can be implemented in a large tertiary care hospital with widespread physician and nursing support.
- Based on our Triage Score, patients selected by physicians for Respiratory Therapy Consultation had more severe respiratory illness than patients whose respiratory care was self-managed by their physicians (ie, Non-Consult patients).
- In this early pilot experience, Consult patients received more types of respiratory care treatments and more total treatments per patient than patients whose respiratory care was directed by their physicians.
- As a likely result of ongoing re-assessment of treatment for Consult patients, modification of patients' respiratory care plans was more frequent when care was directed by the Consult Service vs by their treating physicians.
- Consult patients showed a trend towards longer length of stay and accrued higher respiratory care charges than Non-Consult patients in this study.

Despite increasing attention given to the merits of evaluate-and-treat programs for respiratory therapy and a rising number of individual treatment programs being used over the last decade,[15-17] few comprehensive evaluate-and-treat programs like the Respiratory Therapy Consult Service described in this report have been implemented.[3,5,8,9] As noted by Tietsort and Burton,[17] common obstacles to im-

Table 3. Comparison of Consult vs Non-Consult Patients with Triage Score 4

Group	n	Types of Respiratory Care Services [Mean (SD)]	Total Number of Respiratory Care Treatments [Mean (SD)]	Changes in Respiratory Care after First 24 Hrs [Mean (SD)]	Total Length of Hospital Stay, Days [Mean (SD)]	Total Respiratory Care Charges. $ [Mean (SD)]
Consult	14	3.3 (1.2)	37.9 (29.8)	1.1 (1.3)	14.6 (14.1)	1684 (1689)
Non-Consult	4	2.8 (2.4)	10.8 (9.9)	0.5 (1.0)	11.3 (4.1)	400 (387)*

*$p < 0.05$, Mann-Whitney rank sum test.

plementing such a comprehensive evaluate-and-treat respiratory therapy program include (1) physician resistance to the program, based on concerns over patient control, (2) therapist resistance (based on lack of familiarity with evaluate-and-treat programs, reluctance to leave the 'comfort' of traditional practice, and/or misgivings about their own assessment skills needed to participate in an evaluate-and-treat program), (3) administration-based resistance (based on concerns about quality assurance, fiscal concerns, liability exposure, and medical director involvement and commitment to such a program), and (4) nursing resistance (based on potential role conflicts with respiratory therapy).

To the extent that each of these factors may be magnified in a large, tertiary care medical center where the number of therapists is greater, yearly staff turnover may be greater, and where the medical, nursing, and administrative staff is larger, it is perhaps not surprising that most of the comprehensive programs currently in place are in relatively smaller medical centers. Despite the larger size of the Cleveland Clinic Foundation (approximately 1,100 beds and 600 staff physicians), our pilot experience and subsequent expansion of the Respiratory Therapy Consult Service to hospital-wide availability demonstrates that implementation in a large, tertiary care medical center is possible. In addition to abiding by previous recommendations for assuring successful implementation of the Consult Service, local features that have facilitated acceptance of the program include (1) a highly organized multispecialty group practice (with enhanced flexibility and communication about new programs), and (2) availability of previous studies at the Cleveland Clinic demonstrating misallocation of respiratory care services under an earlier system of exclusively physician-directed respiratory care. In a retrospective review of 230 adult non-ICU inpatients for whom respiratory care was ordered, Kester and Stoller[2] reported that 25.2% of respiratory care orders were deemed unlikely to provide clinical benefit, even when lenient appropriateness criteria were applied. At the same time, 11.2% of these same patients were deemed fitting candidates for respiratory care that was not ordered for them, establishing the presence of "misallocation" of respiratory care.

Surgeons in the current study selected Respiratory Therapy Consultation for patients with lower Triage Scores (ie, more respiratory sickness), while electing to self-manage patients whose Triage Scores suggested less severe degrees of respiratory impairment. In the absence of prior evidence that the Respiratory Therapy Consult Service was effective in this pilot study, we interpret the surgeons' seeking consultative help with their sicker patients to reflect their confidence in the service.

In the context that the Respiratory Therapy Consult Service was created to prevent misallocation of respiratory care services that had been observed previously, the observations that Consult patients in the current pilot study received more types of respiratory care services, more total services, and more adjustment of respiratory care activities require interpretation. One possible explanation is that the greater allocation of respiratory care services to these Consult patients is in keeping with their greater degree of respiratory illness, as indicated by their having been assigned more Triage Points and lower Triage Scores (ie, more severe respiratory involvement) than Non-Consult patients. However, because the appropriateness of respiratory care treatment was not evaluated independently in this pilot study, the current study cannot assess whether the greater amount of respiratory care given to Consult patients was justifiable. Overall, several explanations may account for the higher respiratory care charges in Consult patients, including: (1) Consult patients are sicker and require more care; (2) physicians are under-treating Non-Consult patients; (3) therapists are treating Consult patients too vigorously, either because the algorithms specify over-treatment or because algorithms are not being followed uniformly; and (4) the data reflect a sampling bias related to the small study size.

While none of these potential explanations can be excluded, we suspect that the higher charges accrued by Consult patients reflect a combination of their greater degree of acuity and overzealous treatment by therapists soon after the inception of the Respiratory Therapy Consult Service in February, 1992. We further suspect that overzealous treatment was especially evident soon after launching the RTCS, when therapists' enthusiasm for the

Consult Service and commitment to its success (eg, by unusually close patient follow-up) was especially high.

The current finding of higher respiratory care charges associated with the Respiratory Therapy Consult Service is at odds with the observation by Tietsort and Burton[17] that DRG-specific respiratory care charges were lower in a hospital using an evaluate-and-treat program (Lutheran Medical Center, Wheat Ridge CO) than at nearby hospitals not employing such a program. However, as in the current study, accurate interpretation of these charge data requires assurance that the compared patients had similar degrees of severity of illness and received appropriate respiratory care in the evaluate-and-treat program. As such, full interpretation of respiratory care charges, whether higher or lower than with traditional respiratory care practice, requires better understanding of appropriateness of treatment than is currently available in studies of evaluate-and-treat programs.

To the extent that the current research reports the results of a pilot experience with the Respiratory Therapy Consult Service at our institution, several uncertainties remain, as summarized by these questions:

- Can we be confident that the patients allocated to the Respiratory Therapy Consult Service were truly sicker than Non-Consult patients? This question focuses on the validity of the Triage Points and Triage Score as indicators of respiratory involvement. Indeed, this triage system, which has since been adopted by others,[17] was initially developed at the Cleveland Clinic Foundation to select patients least in need of therapy when orders outstripped available staff and capabilities. Though useful as an operational instrument in our institution, studies to validate the scoring system are needed.

- Besides presumed differences in degree of respiratory illness, are patients allocated to physician-directed care vs Consult care otherwise similar, so that differences in outcome (eg, length of stay) can be ascribed to the type of service? This question recognizes that because allocation of patients to Consult vs Non-Consult care was not randomized in this study, we cannot assure that patients in both groups were similar. Therefore, differences in patient outcome cannot be ascribed confidently to the differences between Consult and Non-Consult care. This potential shortcoming can best be addressed by conducting a randomized clinical trial, plans for which are currently under way at our institution. To date, available randomized trials of Consult services are limited to studies of geriatric care[18-21] and management of anticoagulant therapy.[22]

- Can we be confident that the higher charges associated with the Respiratory Therapy Consult Service are appropriate? Although higher charges may be in keeping with Consult patients' ratings of being sicker, endorsement of a Consult Service requires demonstrating that care plans administered by the Consult Service are appropriate based on independent assessment by unbiased, informed observers. As a follow-up to the current study, prospective assessment of the Consult Service with comparison of Consult vs Non-Consult patient care plans to those of an independent auditor using the algorithms is currently under way at the Cleveland Clinic. Preliminary data from this prospective study suggest that the frequency of inappropriate orders for respiratory care services is lower on the Consult Service than with physician-directed Non-Consult care.[23]

- Can the results of this study be widely applied? The current study was conducted on a single ward caring for a relatively homogenous patient group. As such, generalizability of these conclusions cannot be assured but requires study of a larger, more diverse study group.

In summary, the current study reports our early experience with the Respiratory Therapy Consult Service at the Cleveland Clinic Foundation. This experience shows that such a program can be implemented successfully at a large tertiary care institution with widespread physician and nursing support. Although our experience is promising, whether the RTCS satisfies its avowed goal of ameliorating misallocation of respiratory care has yet to be proven and awaits the completion of other studies currently under way or being planned at our institution.

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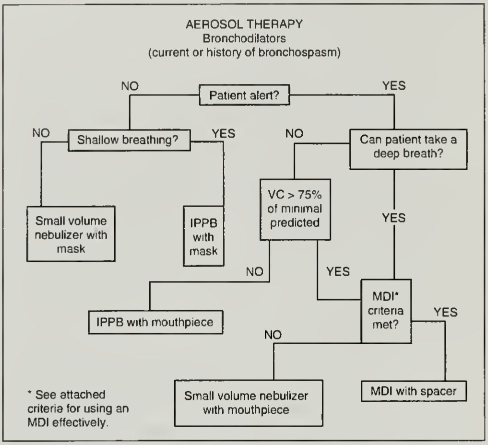
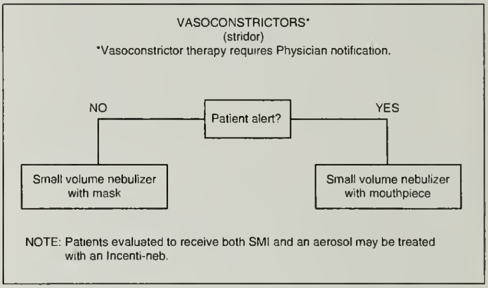
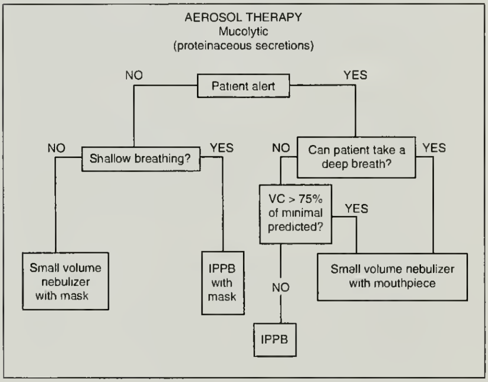
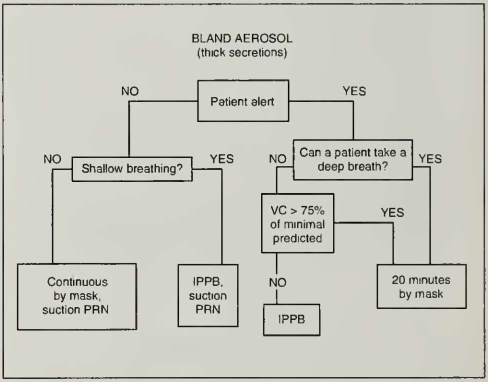
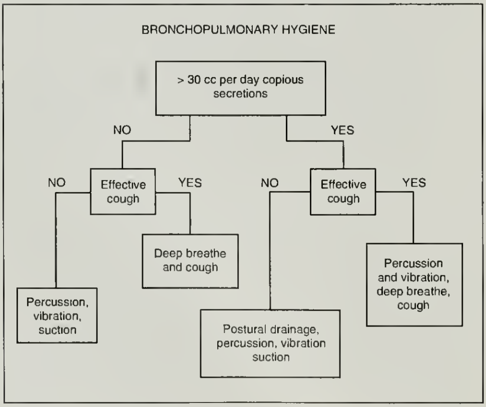
Appendix 1. Algorithms for treatments included in the Respiratory Therapy Consult Service.

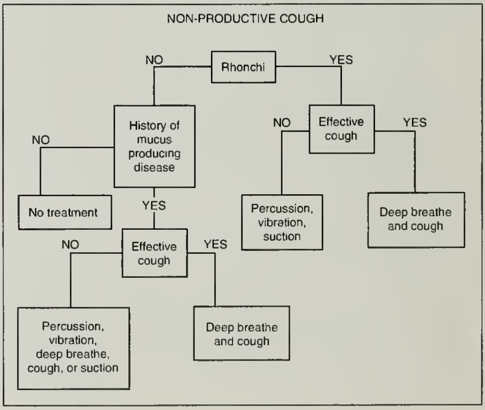

AEROSOL THERAPY
Bronchodilators
(current or history of bronchospasm)
NO
Patient alert?
YES
NO
Shallow breathing?
YES
NO
Can patient take a deep breath?
Small volume nebulizer with mask
IPPB with mask
VC > 75% of minimal predicted
YES
NO
YES
IPPB with mouthpiece
MDI* criteria met?
YES
NO
Small volume nebulizer with mouthpiece
MDI with spacer
* See attached criteria for using an MDI effectively.


VASOCONSTRICTORS*
(stridor)
*Vasoconstrictor therapy requires Physician notification.
NO
Patient alert?
YES
Small volume nebulizer with mask
Small volume nebulizer with mouthpiece
NOTE: Patients evaluated to receive both SMI and an aerosol may be treated with an Incenti-neb.


AEROSOL THERAPY
Mucolytic
(proteinaceous secretions)
NO
Patient alert
YES
NO
Shallow breathing?
YES
NO
Can patient take a deep breath?
YES
VC > 75% of minimal predicted?
YES
Small volume nebulizer with mask
IPPB with mask
NO
Small volume nebulizer with mouthpiece
IPPB

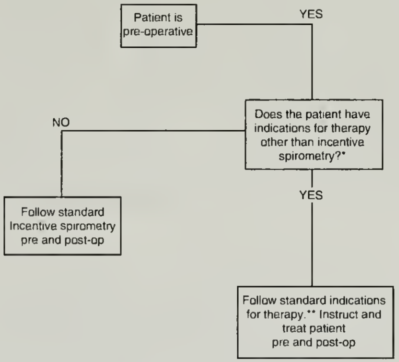



BRONCHOPULMONARY HYGIENE
> 30 cc per day copious secretions
NO
YES
NO
Effective cough
YES
NO
Effective cough
YES
Deep breathe and cough
Percussion and vibration, deep breathe, cough
Percussion, vibration, suction
Postural drainage, percussion, vibration suction



Appendix 1, continued

PRE-OPERATIVE THERAPY AND/OR TEACHING


Patient is pre-operative
YES
Does the patient have indications for therapy other than incentive spirometry?*
NO
Follow standard Incentive spirometry pre and post-op
YES
Follow standard indications for therapy.** Instruct and treat patient pre and post-op

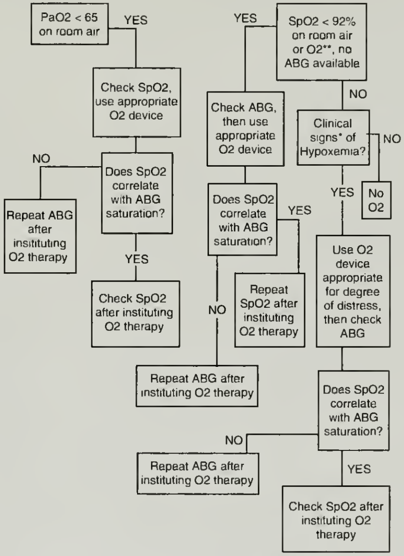
*Indications for Incentive Spirometry:
1. Atelectasis
2. Decreased lung volumes
3. Complete bed rest
4. Prevention of atelectasis

** See indications and appropriate algorithms for other therapy.

NOTE: All pre-op Consult patients will be re-evaluated and followed post-operatively.

CARE PLAN GUIDELINES OXYGEN THERAPY

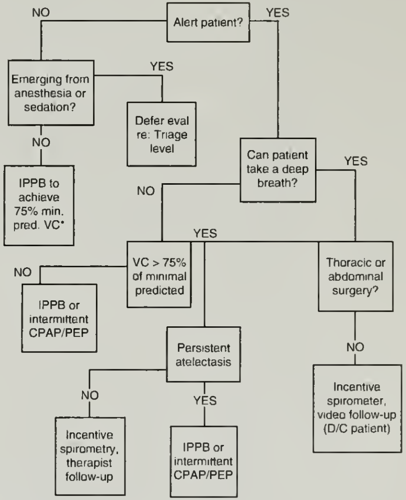
Indications:
1. PaO2 < 65 on RA
2. SpO2 < 92% on RA
3. Clinical signs*


PaO2 < 65 on room air
YES
Check SpO2, use appropriate O2 device
Does SpO2 correlate with ABG saturation?
NO
Repeat ABG after insitituting O2 therapy
YES
Check SpO2 after instituting O2 therapy
SpO2 < 92% on room air or O2**, no ABG available
YES
Check ABG, then use appropriate O2 device
Does SpO2 correlate with ABG saturation?
YES
Repeat SpO2 after instituting O2 therapy
NO
Repeat ABG after instituting O2 therapy
NO
Clinical signs* of Hypoxemia?
NO
No O2
YES
Use O2 device appropriate for degree of distress, then check ABG
Does SpO2 correlate with ABG saturation?
NO
Repeat ABG after instituting O2 therapy
YES
Check SpO2 after instituting O2 therapy

* SOB, tachycardia, diaphoresis, contusion, chest pain, cardiac history.
** Patients already on O2 titrated as appropriate.

CARE PLAN GUIDELINES HYPERINFLATION THERAPY

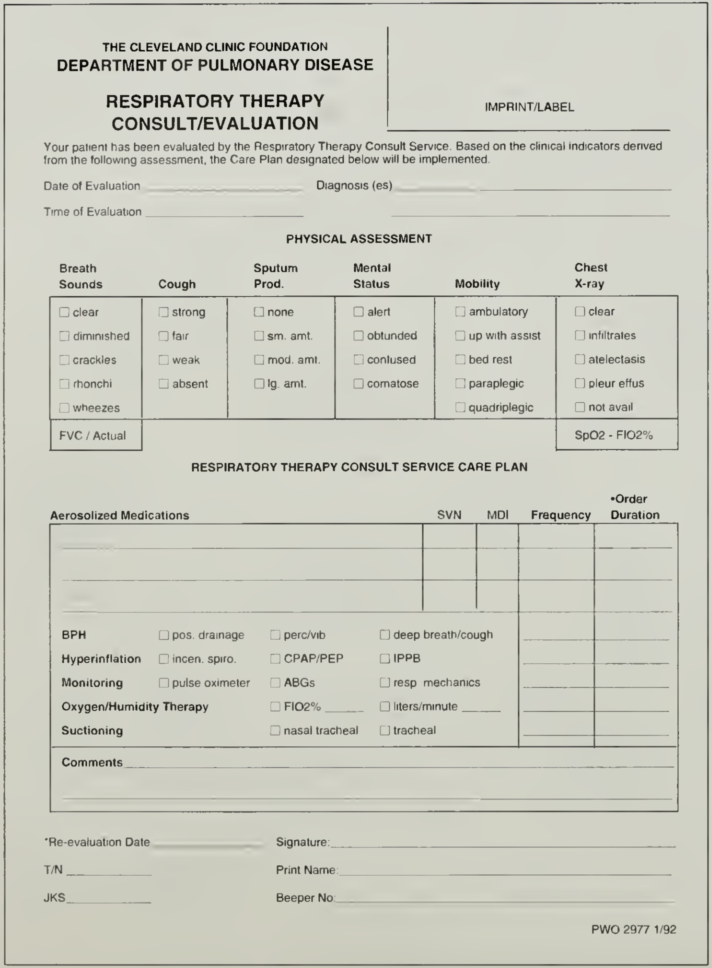
Indications
1. Atelectasis
2. Decreased lung volumes
3. Complete bed rest
4. Prevention of atelectasis


Alert patient?
NO
Emerging from anesthesia or sedation?
YES
Defer eval re: Triage level
NO
IPPB to achieve 75% min. pred. VC*
YES
Can patient take a deep breath?
NO
VC > 75% of minimal predicted
NO
IPPB or intermittent CPAP/PEP
YES
Persistent atelectasis
NO
Incentive spirometry, therapist follow-up
YES
IPPB or intermittent CPAP/PEP
YES
Thoracic or abdominal surgery?
NO
Incentive spirometer, video follow-up (D/C patient)

Note: Patients evaluated to receive both SMI and aerosol may be treated with an Incenti-neb.
Table for predicted minimal vital capacities should be consulted.

* Using mouth seal or face mask

Appendix 2. Care Plan form for Respiratory Therapy Consult.



THE CLEVELAND CLINIC FOUNDATION
DEPARTMENT OF PULMONARY DISEASE

RESPIRATORY THERAPY CONSULT/EVALUATION

IMPRINT/LABEL

Your patient has been evaluated by the Respiratory Therapy Consult Service. Based on the clinical indicators derived from the following assessment, the Care Plan designated below will be implemented.

Date of Evaluation ______ Diagnosis (es) ______

Time of Evaluation ______

PHYSICAL ASSESSMENT

Breath Sounds	Cough	Sputum Prod.	Mental Status	Mobility	Chest X-ray
☐ clear	☐ strong	☐ none	☐ alert	☐ ambulatory	☐ clear
☐ diminished	☐ fair	☐ sm. amt.	☐ obtunded	☐ up with assist	☐ infiltrates
☐ crackles	☐ weak	☐ mod. amt.	☐ confused	☐ bed rest	☐ atelectasis
☐ rhonchi	☐ absent	☐ lg. amt.	☐ comatose	☐ paraplegic	☐ pleur effus
☐ wheezes				☐ quadriplegic	☐ not avail
FVC / Actual					SpO2 - FIO2%

RESPIRATORY THERAPY CONSULT SERVICE CARE PLAN

Aerosolized Medications	SVN	MDI	Frequency	•Order Duration

				Frequency	•Order Duration
BPH	☐ pos. drainage	☐ perc/vib	☐ deep breath/cough		
Hyperinflation	☐ incen. spiro.	☐ CPAP/PEP	☐ IPPB		
Monitoring	☐ pulse oximeter	☐ ABGs	☐ resp mechanics		
Oxygen/Humidity Therapy		☐ FIO2% ______	☐ liters/minute ______		
Suctioning		☐ nasal tracheal	☐ tracheal		

Comments ______

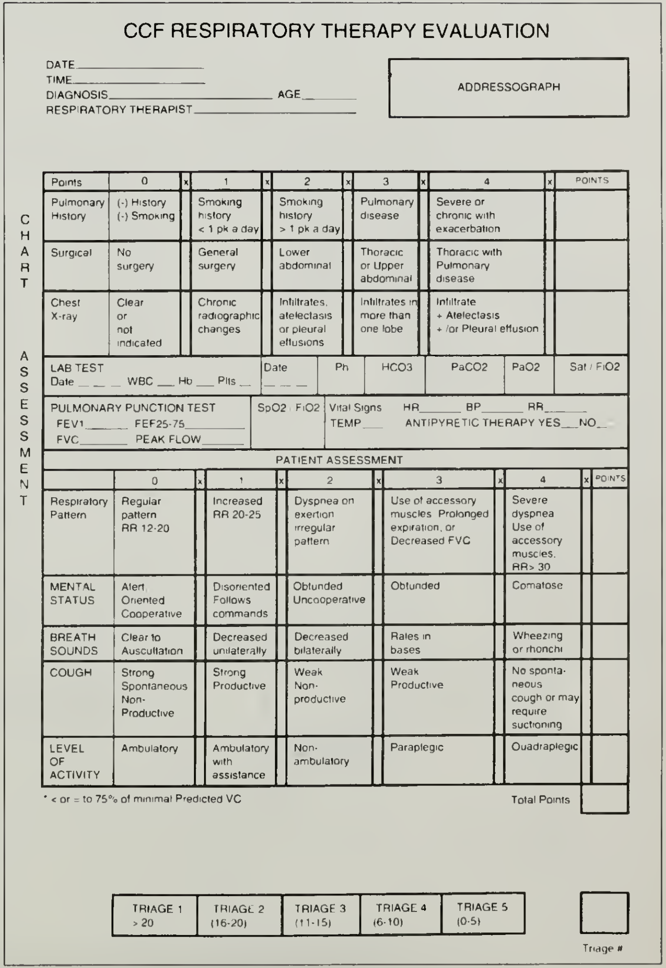
*Re-evaluation Date ______ Signature: ______

T/N ______ Print Name: ______

JKS ______ Beeper No: ______

PWO 2977 1/92

Appendix 3. Triage Score rating form for Respiratory Therapy Consult.



CCF RESPIRATORY THERAPY EVALUATION

DATE ______
TIME ______
DIAGNOSIS ______ AGE ______
RESPIRATORY THERAPIST ______

ADDRESSOGRAPH

CHART

Points	0	x	1	x	2	x	3	x	4	x	POINTS
Pulmonary History	(-) History (-) Smoking		Smoking history < 1 pk a day		Smoking history > 1 pk a day		Pulmonary disease		Severe or chronic with exacerbation		
Surgical	No surgery		General surgery		Lower abdominal		Thoracic or Upper abdominal		Thoracic with Pulmonary disease		
Chest X-ray	Clear or not indicated		Chronic radiographic changes		Infiltrates, atelectasis or pleural effusions		Infiltrates in more than one lobe		Infiltrate + Atelectasis + /or Pleural effusion		

ASSESSMENT

LAB TEST
Date __ __ __ WBC ___ Hb ___ Plts ___

Date	Ph	HCO3	PaCO2	PaO2	Sat / FiO2
__ __ __					

PULMONARY PUNCTION TEST
FEV1 ______ FEF25-75 ______
FVC ______ PEAK FLOW ______

SpO2 / FiO2

Vital Signs HR ______ BP ______ RR ______
TEMP ___ ANTIPYRETIC THERAPY YES ___ NO ___

PATIENT ASSESSMENT

	0	x	1	x	2	x	3	x	4	x	POINTS
Respiratory Pattern	Regular pattern RR 12-20		Increased RR 20-25		Dyspnea on exertion irregular pattern		Use of accessory muscles Prolonged expiration, or Decreased FVC		Severe dyspnea Use of accessory muscles. RR> 30		
MENTAL STATUS	Alert, Oriented Cooperative		Disoriented Follows commands		Obtunded Uncooperative		Obtunded		Comatose		
BREATH SOUNDS	Clear to Auscultation		Decreased unilaterally		Decreased bilaterally		Rales in bases		Wheezing or rhonchi		
COUGH	Strong Spontaneous Non-Productive		Strong Productive		Weak Non-productive		Weak Productive		No spontaneous cough or may require suctioning		
LEVEL OF ACTIVITY	Ambulatory		Ambulatory with assistance		Non-ambulatory		Paraplegic		Quadraplegic		

* < or = to 75% of minimal Predicted VC

Total Points ______

TRIAGE 1	TRIAGE 2	TRIAGE 3	TRIAGE 4	TRIAGE 5
> 20	(16-20)	(11-15)	(6-10)	(0-5)

Triage #

Residual Bacterial Contamination on Reusable Pulse Oximetry Sensors

Martin C Wilkins BS RRT

BACKGROUND: An earlier study demonstrated that standard cleaning techniques did not adequately disinfect reusable pulse oximetry sensors that had been intentionally contaminated with high titers of pathogenic microorganisms. This current study evaluated patient-ready sensors being used in hospitals, by testing them for bacterial contamination. METHODS: Reusable pulse oximetry sensors from 15 hospitals throughout the United States were tested. Each sensor was deemed by the hospital to be ready for patient use, and it had been prepared for use according to hospital procedures. Patient-contact areas of each sensor were swabbed, and the swabs were analyzed for bacterial contamination using standard testing procedures. This study had two stages, and different sensors were tested in each stage. In the "bacterial-growth stage," swabs were evaluated for bacterial contamination but organisms were not identified; in the "identification stage," bacterial species were identified. RESULTS: Forty-four sensors were evaluated, 16 in the bacterial-growth stage and 28 in the identification stage. Bacteria were cultured from 29 of the 44 sensors (66%), including 20 that had been cleaned with alcohol or an antibacterial/antiviral agent. Among the isolated organisms were *Staphylococcus aureus, Staphylococcus haemolyticus, Enterococcus faecalis,* and *Klebsiella oxytoca.* Bacterial contamination was found on sensors from 12 of the 15 participating hospitals. CONCLUSIONS: These data demonstrate the need to define effective cleaning methods for reusable sensors, and we are currently conducting such studies. The data also suggest that disposable patient-dedicated sensors may be the most appropriate choice when infection control is of particular concern. [Respir Care 1993;38(11):1155-1160.]

Introduction

Cost containment efforts commonly bring pressure to replace disposable products with their reusable counterparts, and in any such decision, infection control considerations are crucial. Reusable medical devices have served as vehicles for hospital-acquired (nosocomial) infections, and incidence data suggest that nosocomial infection may be 1 of the 10 leading causes of death in the United States.[1] These studies indicate that nosocomial infections affect approximately 5% of the patients in U.S. acute-care hospitals, directly causing the deaths of slightly fewer than 1% of these patients and contributing to the deaths of approximately 3% more.[1-3] These infections lengthen hospital stay by an average of 4 days per infected patient and increase annual healthcare costs by an estimated $4.5 billion.[1]

Reusable medical devices that are invasive are more commonly associated with nosocomial infections than are noninvasive ones.[4] However, various noninvasive devices (including reusable ECG electrode bulbs,[5,6] blood pressure cuffs,[7] and stethoscopes[8,9]) have been implicated. Results from this investigator's earlier work suggests that reusable pulse oximetry sensors could harbor pathogenic microorganisms.[10] In that study, reusable sensors were applied to a gloved hand that had been inoculated with high titers of *Staphylococcus aureus, Pseudomonas aeruginosa,* and *Candida albicans.* Although the sensors were then carefully cleaned with

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This study was funded, in part, by a Grant from Nellcor Inc, Hayward, California.

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70% isopropyl alcohol, colonization by *P aeruginosa* and *C albicans* persisted.

I now report results from a study assessing bacterial contamination of patient-ready reusable pulse oximetry sensors used in hospitals. This study evaluates sensors that have been made ready for use (cleaned) using the typical clinical procedures of the individual, participating hospital.

Methods

Samples for bacterial analysis were obtained from reusable pulse oximeter sensors. These sensors had been identified by hospital staff as ready for use on the next patient. They had been prepared for patient use according to hospital procedures; preparation methods ranged from cleaning with an antibacterial/antiviral agent to no cleaning.

Forty-four sensors from 15 acute-care hospitals were evaluated using an observational study design to ascertain the prevalence of bacterial colonization among patient-ready, reusable pulse-oximetry sensors. Various models of reusable sensors from 6 manufacturers were evaluated from teaching and nonteaching hospitals throughout the U.S. Participating hospitals were guaranteed anonymity. Following the same protocol, 5 individuals collected samples. Samples were collected aseptically using commercially available swabs* moistened with sterile modified Stuart's bacterial transport medium (sodium glycerophosphate, 1.0%; sodium thioglycolate, 0.1%; calcium chloride, dihydrate, 0.01%; water). All sensor surfaces that normally contact patient skin or nail were swabbed; the cable, plug, and outer surface of the sensor were not swabbed. Swabs were immediately immersed in sterile bacterial transport medium and sent to an independent laboratory for analysis.

This study was conducted in two stages, and different sensors were evaluated during each stage. In one stage, the swabs were tested for bacterial contamination but organisms were not identified; this portion of the study is referred to as the "bacterial-growth stage." Because bacteria were found on a significant number of the sensors evaluated in the bacterial-growth stage of the study, the protocol was modified to include identification of bacterial species; this portion of the study is referred to as the "identification stage."

In the bacterial-growth stage of the study, collected swabs were plated on nonselective media, incubated at 35 ± 2°C and examined daily for growth. Plates were incubated for a maximum of 7 days.

The identification stage of the study used the incubation protocol just described. Then, isolated colonies were Gram stained and subcultured on nonselective media at 35 ± 2°C for an additional 24 hours or until growth was seen. Gram staining was repeated to ensure purity of culture. Next, the cultures were inoculated onto Micrologplates or Staph-Ident test strips. If the organism morphology suggested a *Staphylococcus* or *Micrococcus* species, the colony was inoculated on a Staph-Ident test strip, which provides an accurate screening test for those species. All others were inoculated onto Micrologplates, which identify a broader range of bacterial species. Micrologplates were incubated for 4 hours at 35 ± 2°C, scored, incubated for an additional 20 hours at the same temperature, and then scored again. Staph-Ident strips were incubated for 5 hours at 35 ± 2°C in a CO_2-free incubator and then scored. Based on these results, additional tests were performed using standard procedures to identify each isolate.[11-14]

Results

Forty-four reusable pulse oximetry sensors were sampled, 16 in the bacterial-growth stage of the study and 28 in the identification stage. These sensors were obtained from 15 hospitals in various regions of the United States. The hospitals ranged in size from 150 to 600 beds and included five teaching institutions.

The sensors had been prepared for patient use by methods ranging from cleaning with an antibacterial/antiviral agent to no cleaning. The sensors had been used in various departments, including the emergency department, respiratory therapy, the pulmonary laboratory, the general care floor, the post-anesthesia care unit, and in the neonatal, pediatric, adult, and respiratory intensive-care units. The identification stage of the study focused on organism identification and included sensors from 6 manufacturers (see Products and Services at the end of text).

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*Suppliers are identified in the Products and Services section at the end of the test.

However, for the bacterial-growth phase, sensors from only one manufacturer were included.

The findings of the bacterial-growth stage of the study are summarized in Table 1. Bacterial contamination was found on 50% of the 16 patient-ready sensors evaluated in this stage of the study. Interestingly, only 1 of the 8 contaminated sensors had not been cleaned at all; the remaining 7 had been cleaned with 70% isopropyl alcohol. Based on these findings, it clearly was desirable to identify the contaminating organisms.

The organisms cultured in the identification stage of the study are listed in Table 2. Seventy-five percent of the 28 patient-ready sensors in this stage of the study were contaminated with bacteria. Among the organisms were *Staphylococcus aureus, Staphylococcus haemolyticus, Enterococcus faecalis,* and *Klebsiella oxytoca.* Only 8 of the 21 contaminated sensors had not been cleaned; the remaining 13 had been cleaned with alcohol or a disposable germicidal cloth. When the data from the bacterial-growth and identification stages of the study are pooled, it can be seen that bacteria were cultured from 29 (66%) of the 44 sensors, all of which had been deemed "ready-for-patient-use" (Table 3).

Bacterial contamination was found on sensors from 12 of the 15 participating hospitals. No bacteria were cultured from samples obtained at three hospitals: a 300-bed, nonteaching hospital participating in the bacterial-growth stage of the study; a 550-bed, teaching hospital in the bacterial-growth stage; and a 150-bed, nonteaching hospital in the identification stage. These three hospitals used 70% isopropyl alcohol to clean the sensors.

Discussion

Although no published reports have implicated pulse oximetry sensors in nosocomial infections, other reusable noninvasive devices have served as environmental reservoirs of infection. For example, a reusable blood pressure cuff was associated with

Table 1. Sensors Evaluated in the Bacterial-Growth Stage of the Study

Type of Hospital	Department	Sensor Manufacturer	Cleaning Agent	Bacteriological Findings*
400 beds nonteaching	Postanesthesia care†	Nellcor	No cleaning	2 species
	Postanesthesia care	Nellcor	1:10 bleach solution	No growth
	Postanesthesia care	Nellcor	1:10 bleach solution	No growth
	Respiratory therapy	Nellcor	70% isopropyl alcohol	1 species
550 beds teaching	Respiratory therapy	Nellcor	70% isopropyl alcohol	No growth
	Surgery	Nellcor	70% isopropyl alcohol	No growth
250 beds nonteaching	Pulmonary function laboratory	Nellcor	70% isopropyl alcohol	1 species
	Pulmonary function laboratory	Nellcor	70% isopropyl alcohol	1 species
300 beds nonteaching	Respiratory therapy	Nellcor	70% isopropyl alcohol	2 species
	Respiratory therapy	Nellcor	70% isopropyl alcohol	No growth
550 beds teaching	Postanesthesia care	Nellcor	70% isopropyl alcohol	No growth
	Postanesthesia care	Nellcor	70% isopropyl alcohol	3 species
	Postanesthesia care	Nellcor	70% isopropyl alcohol	2 species
150 beds nonteaching	Respiratory therapy	Nellcor	70% isopropyl alcohol	4 species
300 beds nonteaching	Emergency	Nellcor	70% isopropyl alcohol	No growth
	Emergency	Nellcor	70% isopropyl alcohol	No growth

*Organisms were not identified in this stage of the study.

†Department used various methods to prepare sensors for patient use; some reusable sensors were not cleaned.

Table 2. Sensors Evaluated in the Identification Stage of the Study

Type of Hospital	Department	Sensor Manufacturer	Cleaning Agent	Bacteriological Findings
200 beds, nonteaching	Respiratory therapy	Biochem	No cleaning*	*Staphylococcus hominis*
	Respiratory therapy	Biochem	No cleaning*	*Staphylococcus auricularis*
	Respiratory therapy	Criticare	No cleaning*	*Micrococcus luteus*
	Respiratory therapy	Criticare	No cleaning*	*Staphylococcus hominis*
	Respiratory therapy	Criticare	No cleaning*	*Staphylococcus hominis* *Gemellum morbillorum*
250 beds, nonteaching	Respiratory therapy	Nellcor	No cleaning*	*Staphylococcus cohnii*
450 beds, teaching	Intensive care	Biochem	No cleaning*	*Staphylococcus epidermidis*
	Respiratory therapy	Ohmeda	Unknown	*Staphylococcus epidermidis* *Staphylococcus hominis*
	Emergency	Nellcor	70% isopropyl alcohol	Gram negative (not identified)†
	Emergency	Nellcor	70% isopropyl alcohol	*Staphylococcus hominis*
	Intensive care	Ohmeda	70% isopropyl alcohol	*Staphylococcus haemolyticus* *Enterococcus faecalis*
	Emergency	Ohmeda	70% isopropyl alcohol	*Micrococcus luteus* Gram negative (not identified)† *Micrococcus iylae* *Enterococcus faecalis*
550 beds, teaching	Pediatric intensive care	Hewlett-Packard	70% isopropyl alcohol	*Staphylococcus capitis*
	Neonatal intensive care	Nellcor	70% isopropyl alcohol	No growth
400 beds, nonteaching	Intensive care	Hewlett-Packard	70% isopropyl alcohol	*Enterococcus faecalis* *Staphylococcus cohnii* *Staphylococcus hominis*
	Intensive care	Hewlett-Packard	70% isopropyl alcohol	*Klebsiella oxytoca* *Intrasporagium calvum*
	Postanesthesia care	Ohmeda	Sani-Cloth	*Rothia dentocariosa* *Staphylococcus hominis*
	Postanesthesia care	Ohmeda	Sani-Cloth	*Staphylococcus warneri*
150 beds, nonteaching	Respiratory therapy	InVivo	70% isopropyl alcohol	No growth
	Respiratory therapy	InVivo	70% isopropyl alcohol	No growth
	Respiratory therapy	InVivo	70% isopropyl alcohol	No growth
	Respiratory therapy	Nellcor	70% isopropyl alcohol	No growth
	Respiratory therapy	Nellcor	70% isopropyl alcohol	No growth
600 beds, teaching	Emergency	Hewlett-Packard	70% isopropyl alcohol	*Staphylococcus hominis*
	Floor	Nellcor	70% isopropyl alcohol	*Staphylococcus haemolyticus* *Staphylococcus aureus* *Enterococcus faecalis*
350 beds, nonteaching	Respiratory therapy	Nellcor	70% isopropyl alcohol	*Staphylococcus saprophyticus*
	Respiratory therapy	Nellcor	70% isopropyl alcohol	*Micrococcus luteus* *Streptococcus mitis* *Stomatococcus mucilaginosus*
	Respiratory therapy	Ohmeda	70% isopropyl alcohol	No growth

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*No cleaning = department does not clean reusable sensors.

†Organism did not remain viable long enough for identification to be completed.

Table 3. Residual Bacterial Contamination on Patient-Ready Reusable Sensors

Stage of Study	No. of Sensors	No. of Sensors with Growth (%)
Bacterial-growth stage	16	8 (50%)
Identification stage	28	21 (75%)
Combined Total	44	29 (66%)

the transmission of nosocomial infections in a neonatal intensive care unit.[7] The unit's infection rate decreased markedly when a patient-dedicated (disposable) blood pressure cuff was assigned to each neonate. Previously, one reusable cuff had been used for all infants; that cuff was found to be contaminated with organisms that were causing nosocomial infections. Similarly, an outbreak of *Serratia marcescens* in cardiac surgery patients was controlled by conversion from reusable ECG bulbs to disposable electrodes.[5]

These data indicate that reusable pulse oximetry sensors also could serve as vehicles for nosocomial infection. For example, among the organisms found, *S aureus, S haemolyticus, E faecalis,* and *K oxytoca* are of particular concern. *S aureus,* the most common cause of staphylococcal infections in humans, has been implicated in a range of nosocomial infections, including surgical wound infections, endocarditis, bacteremia, and pneumonia. These infections can be difficult to treat because of the high incidence of resistant strains.[13,14] *S haemolyticus,* the second most commonly encountered coagulase-negative staphylococci in nosocomial infections, has been implicated in native-valve endocarditis, septicemia, peritonitis, and wound infections.[13,14] *E faecalis,* part of the normal human fecal flora, has been identified as an etiologic agent in wound infections and intra-abdominal abscesses. Superinfection by enterococci is relatively common in patients being treated with third generation cephalosporins because strains have developed that are resistant to cephalosporin, as well as to penicillin.[13,14] *K oxytoca* has caused nosocomial infections, including urinary tract infections, bacteremia with focal lesions, and occasionally, pneumonia.[13,14]

Many of the organisms found on these sensors, although normally benign, have been implicated in nosocomial infections, including endocarditis, peritonitis, and pneumonia. Vulnerability to infection and severity of infection are dependent on key patient variables such as immune status, concurrent conditions, and recent invasive procedures. Additionally, patients are at increased risk when normal barriers have been breached, (eg, by surgery, burns, trauma, wounds, or catheters).

The presence of potential pathogens on patient-ready reusable sensors suggests that disposable patient-dedicated sensors might be the most appropriate choice when infection control is a concern. Use of patient-dedicated sensors may be particularly important in intensive care units, where the nosocomial infection rate is somewhat higher than in general ambulatory care units.[15-17] It may also be of particular importance with exceptionally vulnerable patients (eg, those in burn wards).

These findings demonstrate the need for additional research to define cleaning procedures for reusable sensors. Sensor manufacturers are best able to identify effective disinfectants that do not damage the sensor and are safe for patient use. Various agents have been recommended for specific sensors, including alcohol, ethylene oxide, or solutions of bleach, glutaraldehyde, or other cold disinfectants. However, identification of effective cleaning agents will not fully resolve the problem—in this study, some sensors cleaned with a highly effective antibacterial-antiviral agent had residual bacterial contamination, while others were adequately cleaned using 70% isopropyl alcohol. Although isopropyl alcohol is bactericidal for vegetative forms, it is not sporicidal and cannot be considered a sterilant.[18] This suggests that cleaning technique is also crucial and points to an aspect requiring further study. Effective cleaning procedures must be developed and validated by clinical facilities. Such validation studies are already being conducted.

Conclusions

The current healthcare environment requires that managers control their budgets. They must reduce equipment costs, while simultaneously minimizing nosocomial infection and the associated costs. This study questions whether bacterial contamination on reusable pulse oximetry sensors could cause some nosocomial infections. Patient-ready reusable sensors were contaminated and a normally effective disinfecting agent did not always eliminate bacterial contamination. This suggests that cleaning technique may also be crucial.

The decision regarding the purchase of reusable vs disposable pulse oximetry sensors is a cost-benefit issue. Cost-containment pressures are more intense than ever; however, this research suggests the use of patient-dedicated sensors when infection control is a concern (eg, during surgery, with immunocompromised patients, and with those in intensive care units), and the development of more effective cleaning techniques for reusable sensors used with patients at low risk for nosocomial infections.

PRODUCT & SERVICE SOURCES

Pulse Oximetry Sensors:

Biochem International Inc, Waukesha WI
Criticare Systems Inc, Milwaukee WI
Hewlett-Packard Co, Waltham MA
InVivo Research Inc, Winter Park FL
Nellcor Inc, Hayward CA
Ohmeda Monitoring Systems Group Division, Louisville CO

Testing Materials:

Culturette collection and transport system swabs, Becton Dickinson Microbiology Systems, Cockeysville MD
Microlog plates, Biolog Inc, Hayward CA
Staph-Ident test strips, Biomerieux Vitek, St Louis MO

Cleaning Agent:

Sani-Cloth germicidal disposable cloths, Nice-Pak Products Inc, Orangeburg NY

Microbiology Laboratory:

Nelson Laboratories Inc, Salt Lake City UT

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Comparison between Conventional Cap and One-Way Valve in the Decannulation of Patients with Long-Term Tracheostomies

Hai Minh Le BS, James L Aten PhD, Johnson T Chiang, and Richard W Light MD

The purpose of this study was to compare success with the conventional method of capping, or 'plugging,' the tracheostomy tube to success with that of using a one-way-airflow valve, in the decannulation of patients with long-term tracheostomies. MATERIALS & METHODS: To be eligible for the study, the patient had to have had a tracheostomy for at least 30 days and be deemed by his primary care physician to be a candidate for decannulation. Patients who were on mechanical ventilation and patients with sleep apnea syndrome, severe aspiration, or clinically apparent upper-airway obstruction were excluded from the study. Twelve patients who were deemed ready for the decannulation protocol were randomly assigned either to cap or one-way valve. The times of occlusion were increased by 1-hour increments/day up to 6 hours and then by 2-hour increments/day up to 24 hours. RESULTS: Ten patients were successfully decannulated; 5 in each group. The median time for decannulation was 18 days with the one-way valve and 23 days with standard capping. We noted no significant difference in the proportion successfully decannulated or time to decannulation between the two groups ($p > 0.05$). However, patients with the one-way valve appeared to be more comfortable. Pulmonary function testing results varied among and within patients because the patients were unable to cooperate or had uncuffed tubes in place. CONCLUSIONS: In this small group of patients, neither method appeared to be superior, although subjective observation suggested that patients appeared to be more comfortable with the one-way valve. Pulmonary function testing was not useful in predicting successful decannulation. [Respir Care 1993;38(11):1161-1167.]

Background

An adult patient undergoes tracheotomy for one or more of a variety of reasons including prolonged respiratory failure, cerebrovascular accident, head trauma, or spinal cord injury. Once acute problems resolve, the patient with a tracheostomy is often neglected. The patient may be transferred to a medical ward where the care provided is less intensive.

The presence of a tracheostomy has many undesirable effects. (1) The subject is unable to speak and the senses of smell and taste are diminished. (2) Inspired air is not subjected to normal conditioning by the upper airway, which probably contributes to changes such as the loss of cilia in the trachea and major bronchi.[1,2] (3) The tracheobronchial tree becomes colonized with pathogenic bacteria, which can lead to bacterial pneumonia.[3,4] (4) The presence of the tracheostomy may adversely affect swallowing and lead to aspiration.[5-8] (5) The absence of airflow through the larynx may lead to an increase in the resistance of the larynx to airflow.[7] (6) The tracheostomy tube itself may increase airway resistance.[9]

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In view of these adverse effects, it seems apparent that many patients with long-term tracheostomies would benefit from decannulation. However, studies investigating the optimal way to accomplish decannulation are scarce. Although the literature on respiratory care contains numerous references detailing procedures for weaning patients from mechanical ventilation, the literature on weaning from tracheal cannulation is sparse and much of it is concerned with pediatric patients. In this study, we compared a decannulation protocol using conventional capping to one using a one-way valve, in order to develop a practical, safe, and simple way to accomplish decannulation in adult patients.

Three techniques have been advocated for weaning patients from tracheostomy. In the first technique, progressively smaller tracheostomy tubes are used.[10,11] Then, when the tube has been reduced to Size 5 (ie, outside diameter = 5 mm), it is 'corked,' or capped, for progressively longer periods. When the patient can tolerate the occlusion for 24 hours, the tube is removed. The disadvantage of this technique is that if decannulation fails, operative intervention is sometimes required to replace the small tube with a larger one. The second technique calls for replacement of the conventional tube with a cuffed fenestrated tube of the same size. If the patient can breathe satisfactorily through the fenestrated tube for 24 to 48 hours with the external opening of the tracheostomy tube occluded, the tube is removed. Problems associated with this technique are (1) the fenestrations may be occluded by the tracheal mucosa,[11] (2) the presence of the tracheostomy tube may markedly increase airway resistance,[9] and (3) it is sometimes difficult for the patient to clear his secretions past the tracheostomy tube because the tube partially occludes his trachea. The third technique involves the replacement of the tube with a tracheal button,[12] such as the Olympic Trach-Button.* These hollow, Teflon tubes with serrated distal ends are inserted into the tracheal stoma where they rest against the anterior tracheal wall. The button maintains the stoma tract and allows the patient to breathe and clear secretions through his upper airway. The patient can be suctioned or ventilated when the plug is removed from the button. Disadvantages associated with the use of the tracheal button include difficulty in selecting the correct size and length of the button[12] and accidental aspiration or expulsion of the button.[13]

A one-way valve can be combined with any of the above techniques. When a one-way valve is placed on the tracheostomy tube (or on the button), air enters the trachea through the valve, which has a relatively low resistance (5.97-6.27 cm $H_2O \cdot s \cdot L^{-1}$, as measured in our laboratory), and exits through the upper airway. Such valves have 3 theoretical advantages: (1) Because valve resistance is relatively low, patients may need to generate less inspiratory pressure than is required to breathe through their upper airway (if upper airway resistance is increased). This decreased resistance through the valve should delay the onset of respiratory muscle fatigue and facilitate decannulation. (2) The use of a one-way valve should facilitate the clearance of secretions. The expiratory flow, which goes around the outside of the tracheostomy tube, is in the direction of the larynx, and all inspiratory flow is through the tracheostomy tube. (3) One-way-valve use provides airflow through the larynx and should assist in the reestablishment of laryngeal reflex activity, phonation, and cough.[14]

Several types of one-way-airflow valves have been introduced that are readily adaptable to most standard tracheal cannulae. Olympic Trach-Talk and the Passy-Muir Tracheostomy Speaking Valve are two that are commonly used. The Olympic Trach-Talk was designed primarily for ventilator-dependent patients and may be less appropriate during weaning from tracheostomy. The Passy-Muir Tracheostomy Speaking Valve was selected for the present study. The third type of one-way-flow valve is incorporated into the Kistner tracheostomy button but is not detachable. Bird and Hudson Companies also manufacture one-way valves, but their design makes them more suitable for incorporation into a ventilator circuit.

The objectives of this study were (1) to compare the rate of success of decannulation between the conventional method of plugging or capping and that using a one-way-airflow valve, and (2) to assess indices from pulmonary function measurements that would identify those patients who are likely to be successfully weaned.

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*Suppliers are listed in the Product Sources section at the end of the text.

Materials and Methods

Patient Selection

To be eligible for the study, patients were required to have had a tracheostomy for more than 30 days and to be judged by their primary physician to be suitable candidates for decannulation. Patients on mechanical ventilation or patients with sleep apnea syndrome, severe aspiration, or clinically apparent upper-airway obstruction were excluded. However, the presence of thick, purulent secretions did not serve as an exclusion criterion for the study.

Materials

In this study, we selected the Passy-Muir valve to be used with the tracheostomy tube. The Passy-Muir valve was chosen because it is simply constructed, it is a one-way valve especially designed for use with tracheostomy tubes, and it is relatively inexpensive (≈ $25.00) The Passy-Muir valve is designed to be attached to the inner cannula of a tracheostomy tube. Fenestrated tracheostomy tubes were placed in our patients prior to the decannulation trial. The inner cannula of the fenestrated tube was transected proximal to the fenestrations in order to make the fenestrations functional.

Protocol

The protocol and written informed consent were approved by the Institutional Review Board. After the patient or his representative gave consent, the patient underwent an initial evaluation consisting of spirometry through the tracheostomy and the mouth and measurements of maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP). The patient then had his tracheostomy capped for 30 minutes. Patients were excluded from further study if they could not tolerate the capping for 30 minutes, or if the P_{aO_2} dropped below 60 torr, or if the P_{aCO_2} increased more than 5 torr during the 30 minutes of capping.

If the patient passed the 30-minute capping test, he was then randomly assigned to capping or a one-way valve. Patients were randomized by choosing one of two slips from a black box; one slip was marked "one-way valve," and the other was marked "standard."

The duration of cannula occlusion was increased, as tolerated, by 1 hour each day. Once the patient tolerated occlusion of the trachea for 6 hours, the time of occlusion was then increased by 2 hours daily, as tolerated, until the occlusion could be tolerated for the entire 24 hours (ie, the time of occlusion was as follows: 1,2,3,4,5,6 then 8,10,12, 14, . . . 24 h). Decannulation was performed when the tracheostomy had been occluded for 72 hours and the patient had required no suctioning through the tracheostomy. If the patient had been randomized to the one-way valve, after 72 hours of tolerating the valve the patient was switched to capping for 72 hours before decannulation. This was done to ascertain that the patient could tolerate inspiring through the upper airway, which probably has much more resistance than the one-way valve. The maximal duration of an attempt at decannulation was 30 days. If the decannulation was unsuccessful after 30 days, the patient was switched to the alternative device but counted as a failure for the original randomization group and for purposes of analysis.

During the decannulation attempts, the patient's MIP, MEP, forced vital capacity (FVC), forced expiratory volume in the first second (FEV_1), and peak expiratory flow (PEF) were monitored three times a week. During the latter part of the study, oxygen saturations of 4 patients were monitored with pulse oximetry. The patient's MIP and MEP were measured as the pressure at the tracheostomy opening while the patient performed a maximal inspiratory maneuver at functional residual capacity or a maximal expiratory maneuver at total lung capacity with the glottis closed. To measure the intratracheal pressure during tidal breathing, the same apparatus was used and the pressure was monitored continuously with an inspiratory force meter.

Statistical Methods

Mean values for number of days to decannulation were evaluated between groups using the Wilcoxon signed rank test. MIP, MEP, and PEF were tested for significance between groups using independent *t* tests. We prospectively decided that the maximum acceptable risk of type I error was 5% (nonsignificance = p > 0.05).

Results

The mean age of the 12 study patients was 51.4 years (range 21-76 y). The duration of tracheostomy ranged from 5 weeks to 7 years with a 6-month median. The primary diagnoses for the 12 randomized patients are shown in Table 1.

Table 1. Diagnoses for 12 Patients Randomized to Decannulation Study

Diagnosis	Number
Cerebrovascular accident	4
Head trauma	3
Spinal-cord injury	2
Respiratory failure for medical reasons	2
Carcinoma of the palate	1

Six patients were initially randomized to the one-way valve and six to the cap. Decannulation was successful in 10 of the 12 patients (5/6 in each group). In Figure 1, the MEP, MIP, and PEF measurements from 10 of the patients are shown. These measurements could not be obtained in two patients (1 in each group) because they were incapable of cooperating and had uncuffed tubes. FVC and FEV_1 results were highly variable and not reproducible within individual patients due to inconsistent patient effort; they did not meet ATS criteria and were not useful in distinguishing between those who would be successfully decannulated and those who would not. These data were not tested for statistical significance.

From Figure 1, it is apparent that the initial values for airway pressures and peak flow were comparable in both groups. They were not statistically significantly different. Also, two patients who failed weaning did not have values that differed substantially from those who were successful. Note that 5 patients with MEPs < 40 cm H_2O were successfully weaned and that 4 patients with MIPs < 40 and 2 patients with MIPs < 20 were successfully weaned.

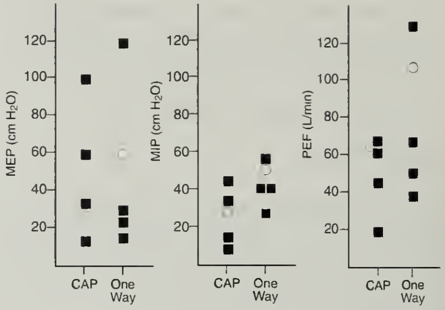

Fig. 1. Initial maximal expiratory pressure (MEP), maximal inspiratory pressure (MIP), and peak expiratory flowrate (PEF) in 10 patients who finished the decannulation protocol. The values in 2 patients who were successfully decannulated could not be obtained because of their inability to cooperate and because both had uncuffed tubes. ○ = patients who failed to decannulate; ■ = patients who were successfully decannulated.

In the 4 patients in whom we measured oxyhemoglobin saturations by pulse oximetry, we observed that with the alarms set on the pulse oximeter, the patient did not have to be directly observed. Rather the nursing and respiratory therapy personnel could perform their other duties and deal with the patient being weaned from the tracheostomy when the alarms sounded. The tracheal pressures varied between +5 cm H_2O and –5 cm H_2O in the 4 patients in whom these pressures were measured. Subsequent patients who could not be weaned had tracheal pressures during tidal breathing of > +10 cm H_2O or < –10 cm H_2O.

Overall, two patients failed to wean to decannulation. Neither patient was able to tolerate the one-way valve for 72 hours. The first had sustained a myocardial infarction and respiratory failure from COPD. During the weaning attempt, his medical condition deteriorated and his primary physician elected to withdraw him from the study. The second, a spinal-cord-injury patient, failed both methods of weaning. He was difficult to work with, and his failure may have been psychologically mediated.

The time to decannulation was slightly shorter (median 18 days, range 14-21 days) with the one-way valve compared to conventional capping (median 23 days, range 8-36 days), but this difference did not achieve statistical significance due to the small number of patients and the inherent variability of the measure. The patients appeared to be more comfortable with the one-way valve, although objective measures of comfort (eg, visual analog scales) were not possible with our patients.

Of the 10 patients in whom decannulation was successful, 5 required surgical stoma closure after decannulation. In the other 5 patients, the stoma closed spontaneously in spite of having had the tracheostomy for years.

Discussion

Because the overall rate of success was identical in both groups, was there evidence that the one-way valve had any advantages over the conventional capping procedure? Probably not, although our subjective assessment suggested that patients appeared to be more comfortable with the one-way valve. In this study weaning from tracheostomy was a labor-intensive process regardless of method.

The present study demonstrates that the standard tests of pulmonary function may not be useful in identifying candidates for decannulation due, at least in part, to the inability of the patients to cooperate.

Pulmonary function testing has been useful in identifying which mechanically ventilated patients are candidates for discontinuance of mechanical ventilation. Measures used have included the vital capacity, MIP, and occlusion pressure in the first 0.1 second of airway occlusion.[15] However, few studies have evaluated the usefulness of pulmonary function testing in predicting successful decannulation. Mallory and colleagues[16] evaluated 40 children (median age 4.5 months, at the time of tracheostomy) who had tracheostomies for an average of 12 months and who were judged clinically ready for decannulation. These researchers found that the ratio of the peak inspiratory flow obtained through the mouth to that obtained through the stoma was useful in predicting successful decannulation. The median ratio for 34 children who were successfully decannulated was 1.40 (just preceding successful attempt) compared to median ratio of 0.83 for the 22 tests in the 6 children who could not be decannulated. However, as our results show, we have been unable to duplicate these results in the adult patient with a long-term tracheostomy because reliable measurements could not be made.

Difficulties were encountered in getting accurate measures of pulmonary function from the majority of patients because of their limited ability to cooperate. Pressure monitoring at the tracheostomy site with the airway occluded gave a very good indication of the MIP and the MEP when the patient coughed. However, MIPs and MEPs were only accurate with cuffed tracheostomy tubes and were not useful in identifying patients who would fail decannulation. Some of the patients had uncuffed tubes so that measures of flowrates or pressures at the tracheostomy were inaccurate.

The most useful screening test that we found during the study was that used to admit patients to the study—the arterial blood gas values before and 30 minutes after the tracheostomy was occluded. If the patient tolerated the occlusion for 30 minutes, if the P_{aCO_2} did not increase by more than 5 torr, and if the P_{aO_2} did not fall below 60 torr, most decannulation attempts (10/12) were successful.

We acknowledge that the present study has several limitations. First, the number of patients is small. However, after we had studied 12 patients it became apparent that our protocol called for increasing the capping time too slowly; therefore, we felt uncomfortable in recruiting additional patients for the study. Second, the conclusions regarding the patient's greater comfort with the one-way valve are not supported by objective data; however, such data are difficult to obtain given the patients' mental status. Third, it was difficult to get accurate measurements with the pulmonary function tests due to the inability of the patients to cooperate fully. Unfortunately, a high percentage of adult patients with tracheostomies are somewhat cognitively impaired.

We have learned much about the difficulties encountered in decannulating tracheostomy patients and our observations include the following:

- Tracheostomy decannulation is a labor-intensive procedure. While the tube is capped, the patient needs to be observed almost continuously. If the patient is not in the intensive care unit or on a well-staffed medical ward, there may not be sufficient personnel to observe the patient.

- It is difficult to know what to monitor in a patient whose ability to communicate is minimal. In order to increase the safety of the decannulation attempt, we monitored the oxyhemoglobin saturation and pulse rate of the last 4 patients by pulse oximetry with the alarms set. Some patients experienced precipitous drops in their S_{pO_2} or heart rate without overt distress.

- Many patients have increased resistance between the stoma and their mouth when the tracheostomy is occluded. We have found that we can obtain an accurate assessment of this increased airway resistance by monitoring the pressure at the tracheostomy opening with the tracheostomy occluded. For most of our patients, the pressure at the tracheostomy with the tracheostomy occluded varies between –5 cm H_2O on inspiration and +5 cm H_2O on expiration. If the tracheal pressures exceed these limits, problems can be anticipated in the decannulation attempt.

- Even though a patient may have increased tracheal pressures early in the decannulation attempt, we found that the pressures may decline with continued short periods of occlusion. This is consistent with results from animal experiments reported by Buckwalter and Sasaki.[7]

- After the decannulation was completed, some patients required surgical closure. Of the 10 patients in whom decannulation was successful, 5 required surgical closure. If the stomal site does not close within 7 days, we recommend that surgical consultation be obtained.

- The protocol that we followed advanced the time of occlusion too slowly. It appeared that many patients could have been advanced much more rapidly. This would markedly decrease the labor involved in the decannulation attempt.

- It has been stated that decannulation attempts should not proceed if the tracheobronchial secretions are thick or purulent.[1] However, we found that thick tracheobronchial secretions were not a contraindication to a decannulation attempt. The volume and the purulence of the secretions decreased after decannulation.

- Although the success rate was no greater with the one-way valve, it appeared to us that the patients were more comfortable with the valve.

Based on our experiences, we recommend that pulse oximetry be utilized throughout the entire weaning period because we believe it decreases the time needed to observe the patient and increases the safety of the procedure. Our recommended protocol is as follows: (1) Obtain arterial blood gases before and after the patient breathes through the one-way valve for 30 minutes. If there is no clinically important deterioration in blood gas values, proceed to the next step. It is probably preferable to use the one-way valve as soon as the patient is discontinued from mechanical ventilation. (2) Insert a fenestrated tracheostomy tube. (3) Attach the one-way valve to the tracheostomy tube and monitor the patient with oximetry. (4) When the patient has tolerated the one-way valve for 48 hours without requiring more than occasional suctioning, cap the tube. This is done to make certain that the patient can tolerate inspiration through the upper airways. Once the tube has been capped for 48 hours during which time no more than occasional suctioning is necessary, remove the tracheostomy tube. If the patient cannot tolerate the full 48 hours, advance the times as tolerated. (5) If difficulties are encountered, measure the pressure at the tracheostomy during tidal breathing. If the pressures are below –5 cm H_2O on inspiration or above +5 cm H_2O on expiration, evaluate the status of the larynx and the endotracheal tube with fiberoptic bronchoscopy. Determine whether suprastomal granulomas are present, whether the vocal cords are adducted, whether the larynx closes during swallowing, and whether the fenestrations are occluded by tracheal mucosa. (6) Consider surgical closure of the tracheal stoma if it remains patent after 7 days.

In Conclusion

In this small group of patients, neither method of decannulation—with conventional capping or with the use of a one-way valve—appeared to be superior, although subjective observation suggested that patients seemed more comfortable with the one-way valve. Pulmonary function testing was not useful in predicting decannulation success. Our experience with this group of patients confirms that decannulation of an adult with a long-term tracheostomy is a labor-intensive procedure.

PRODUCT SOURCES

Tracheostomy Tube Occlusion Alternatives:
Olympic Trach-Button, Olympic Medical, Seattle WA
Kistner Tracheostomy Button, distributed by Pelling Company, Fort Washington PA

Fenestrated Tracheostomy Tube:
Shiley Tracheostomy Products Inc, Irvine CA

One-Way Airflow Valves:
Olympic Trach-Talk, Olympic Medical, Seattle WA
Passy-Muir Tracheostomy Speaking Valve, Model 1985, Passy-Muir Inc, Irvine CA
Bird one-way valve, Bird Products Corp, Palm Springs CA
Hudson one-way valve, Hudson RCI, Temecula CA

Pulmonary Function Equipment:
Vitalograph Inc, Lenexa KS

Pulse Oximeter:
Ohmeda Biox, Ohmeda, Madison WI

Inspiratory Force Meter:
Model 4100, Boehringer Laboratories, Norristown PA

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The American Association for Respiratory Care Clinical Practice Guidelines

- **Transport of the Mechanically Ventilated Patient**
- **Fiberoptic Bronchoscopy Assisting**
- **Resuscitation in Acute Care Hospitals**
- **Intermittent Positive Pressure Breathing**
- **Bland Aerosol Administration**

(Respir Care 1993;38:1169-1200)

Previously Published Guidelines:

- Directed Cough
- Endotracheal Suctioning of Mechanically Ventilated Adults and Children with Artificial Airways
- In-Vitro pH and Blood Gas Analysis and Hemoximetry
- Single-Breath Carbon Monoxide Diffusing Capacity
- Use of Positive Airway Pressure Adjuncts to Bronchial Hygiene Therapy

Respir Care 1993;38:495-521

- Incentive Spirometry
- Pulse Oximetry
- Oxygen Therapy in the Acute Care Hospital
- Spirometry
- Postural Drainage Therapy

Respir Care 1991;36:1398-1426

- Patient-Ventilator System Checks
- Humidification during Mechanical Ventilation
- Selection of Aerosol Delivery Device
- Nasotracheal Suctioning
- Bronchial Provocation
- Exercise Testing for Evaluation of Hypoxemia and/or Desaturation
- Arterial Blood Gas Sampling
- Oxygen Therapy in the Home or Extended Care Facility

Respir Care 1992;37:855,856,882-922

AARC Clinical Practice Guideline

Transport of the Mechanically Ventilated Patient

TMV 1.0 PROCEDURE:

Transportation of a mechanically ventilated patient for diagnostic or therapeutic procedures.

TMV 2.0 DESCRIPTION/DEFINITION:

Transportation of mechanically ventilated patients for diagnostic or therapeutic procedures is always associated with a degree of risk.[1-16] Every attempt should be made to assure that monitoring, ventilation, oxygenation, and patient care remain constant during movement. Patient transport includes preparation, movement to and from, and time spent at destination.

TMV 3.0 SETTINGS:

This guideline is intended for the critical care and acute care inpatient setting.

TMV 4.0 INDICATIONS:

4.1 Transportation of mechanically ventilated patients should only be undertaken following a careful evaluation of the risk-benefit ratio.

4.2 Transportation should be undertaken on the attending physician's order.

TMV 5.0 CONTRAINDICATIONS:

Transportation of the mechanically ventilated patient should not be undertaken until a complete analysis of potential risks and benefits has been accomplished.

5.1 Contraindications include

- **5.1.1** Inability to provide adequate oxygenation and ventilation during transport either by manual ventilation or portable ventilator,[2,17-19]
- **5.1.2** Inability to maintain acceptable hemodynamic performance during transport,[20-22]
- **5.1.3** Inability to adequately monitor patient cardiopulmonary status during transport,[21]
- **5.1.4** Inability to maintain airway control during transport,
- **5.1.5** Transport should not be undertaken unless all the necessary members of the transport team are present.

TMV 6.0 HAZARDS & COMPLICATIONS:

Hazards and complications of transport include the following:

6.1 Hyperventilation during manual ventilation may cause respiratory alkalosis, cardiac dysrhythmias, and hypotension.[2,17,18]

6.2 Loss of PEEP/CPAP may result in hypoxemia.[23]

6.3 Position changes may result in hypotension, hypercarbia, and hypoxemia.[21]

6.4 Tachycardia and other dysrhythmias have been associated with transport.[20-22]

6.5 Equipment failure can result in inaccurate data or loss of monitoring capabilities.[15,16]

6.6 Inadvertent disconnection of intravenous pharmacologic agents may result in hemodynamic instability.[15,16,20]

6.7 Movement may cause disconnection from ventilatory support and respiratory compromise.[23,24]

6.8 Movement may result in accidental extubation.[23]

6.9 Movement may result in accidental removal of vascular access.[4-6,15,16]

6.10 Loss of oxygen supply may lead to hypoxemia.

TMV 7.0 LIMITATIONS OF METHOD:

The literature suggests that nearly two thirds of all transports for diagnostic studies fail to yield results that affect patient care.[15,16]

TMV 8.0 ASSESSMENT OF NEED:

The necessity for transport should be assessed by the attending physician. The risks of transport should be weighed against the potential benefits from the diagnostic or therapeutic procedure to be performed.

TMV 9.0 ASSESSMENT OF OUTCOME:

The safe arrival of the mechanically ventilated patient at his/her destination is the indicator of a favorable outcome.

TMV 10.0 RESOURCES:

10.1 Equipment

10.1.1 Emergency airway management supplies should be available (eg, laryngoscope, endotracheal tubes, stylet, portable suction unit).

10.1.2 Portable oxygen source of adequate volume

10.1.3 A self-inflating bag and mask of appropriate size

10.1.4 Transport ventilators have been shown to provide more constant ventilation than manual ventilation in some instances. If a transport ventilator is used, it should[2,17-19]

10.1.4.1 have independent control of tidal volume and respiratory frequency;[23]

10.1.4.2 be able to provide continuous mechanical ventilation as in assist-control or intermittent mechanical ventilation (not necessarily both);

10.1.4.3 deliver a constant volume in the face of changing pulmonary impedance;

10.1.4.4 monitor airway pressure;

10.1.4.5 provide a disconnect alarm;

10.1.4.6 be capable of providing PEEP;

10.1.4.7 provide an F_{IO_2} of 1.0 (for adults and children). For neonatal transport, precise F_{IO_2} from 0.21 to 1.0 should be available.

10.1.5 A pulse oximeter may be desirable.

10.1.6 Appropriate pharmacologic agents (ACLS) should be readily available.

10.1.7 Portable monitor should display ECG and heart rate and provide at least one channel for vascular pressure measurement.

10.1.8 An appropriate hygroscopic condenser humidifier should be used to provide humidification during transport.

10.1.9 Stethoscope

10.1.10 Hand-held spirometer for tidal volume measurement

10.2 Personnel: All mechanically ventilated patients should be accompanied by a registered nurse and a respiratory care practitioner during the entire transport.

10.2.1 At least one team member must be proficient in endotracheal intubation.

10.2.2 Both team members should be trained in ACLS or PALS as appropriate.

10.2.3 At least one team member should be proficient in operating and troubleshooting all of the equipment described in Section 10.1.

TMV 11.0 MONITORING:

Monitoring provided during transport should be similar to that during stationary care.

11.1 Electrocardiograph should be continuously monitored for signs of dysrhythmias.

11.2 Heart rate should be monitored continuously.

11.3 Blood pressure should be monitored continuously if invasive lines are present. In the absence of invasive monitoring, blood pressure should be measured intermittently via sphygmomanometer.

11.4 Respiratory rate should be monitored intermittently.

11.5 Airway pressures should be monitored if a transport ventilator is used.

11.6 Tidal volume should be monitored intermittently to assure appropriate ventilation.

11.7 Continuous pulse oximetry may be useful in patients with borderline respiratory function.

11.8 Breath sounds should be monitored intermittently.

TMV 12.0 FREQUENCY:

Patient's should be transported only when indications are present as described in Section 4.

TMV 13.0 INFECTION CONTROL:

13.1 Universal Precautions should be observed.[25]

13.2 All equipment should be disinfected between patients.

13.3 Centers for Disease Control and Prevention recommendations for control of exposure to tuberculosis and droplet nuclei are to be implemented when patient is known or suspected to be immunosuppressed, is known to have tuberculosis, or has other risk factors for the disease.[26]

Mechanical Ventilation Guidelines Committee:

Richard D Branson RRT, Chairman, Cincinnati OH
Robert S Campbell RRT, Tampa FL
Robert L Chatburn RRT, Cleveland OH
Jack Covington RRT, San Francisco CA

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AARC Clinical Practice Guideline

Fiberoptic Bronchoscopy Assisting

FBA 1.0 PROCEDURE:

The role of the assistant in flexible fiberoptic bronchoscopy (FFB)

FBA 2.0 DESCRIPTION/DEFINITION:

FFB involves direct visualization of the upper and lower respiratory tract for the diagnosis and management of a spectrum of inflammatory, infectious, and malignant diseases of the chest.[1] FFB may include retrieval of tissue specimens (bronchial brush, forceps, needle), cell washings via bronchoalveolar lavage, or removal of abnormal tissue by laser. FFB is performed by a specially trained physician and assisted by a specially trained healthcare professional (HCP). This guideline addresses the role of the HCP in FFB (Section 10.3).

FBA 3.0 SETTINGS:

The preferred location for FFB is determined by the available equipment, the medical condition of the patient, and the specific procedures to be performed.[2] A designated bronchoscopy room or suite is the preferred location for outpatients or inpatients who are not critically ill. The procedure may be safely performed at the bedside in the intensive care unit, the operating room, an appropriately equipped outpatient facility, or other suitably equipped clinical area.[2]

FBA 4.0 INDICATIONS:

Indications include but are not limited to

4.1 The presence of lesions of unknown etiology on the chest x-ray film or the need to evaluate recurrent or persistent atelectasis or pulmonary infiltrates;[1-5]

4.2 The need to assess patency or mechanical properties of the upper airway;[1,2,4]

4.3 The need to investigate hemoptysis, persistent unexplained cough, localized wheeze, or stridor;[1-6]

4.4 Suspicious or positive sputum cytology results;[1-4]

4.5 The need to obtain lower respiratory tract secretions, cell washings, and biopsies for cytologic, histologic, and microbiologic evaluation;[1,2,5,7,8]

4.6 The need to determine the location and extent of injury from toxic inhalation or aspiration;[1,2,4]

4.7 The need to evaluate problems associated with endotracheal or tracheostomy tubes (tracheal damage, airway obstruction, or tube placement);[1-5]

4.8 The need for aid in performing difficult intubations;[1,2,4,5]

4.9 The suspicion that secretions or mucus plugs are responsible for lobar or segmental atelectasis;[1-4]

4.10 The need to remove abnormal endobronchial tissue or foreign material by forceps, basket, or laser;[1]

4.11 The need to retrieve a foreign body (although under most circumstances, rigid bronchoscopy is preferred).[4,5,9]

FBA 5.0 CONTRAINDICATIONS:

Flexible bronchoscopy should be performed only when the relative benefits outweigh the risks.

5.1 Absolute contraindications include

5.1.1 Absence of consent from the patient or his/her representative unless a medical emergency exists and patient is not competent to give permission;[1]

5.1.2 Absence of an experienced bronchoscopist to perform or closely and directly supervise the procedure;[1,2]

5.1.3 Lack of adequate facilities and personnel to care for such emergencies as cardiopulmonary arrest, pneumothorax, or bleeding;[1,2]

5.1.4 Inability to adequately oxygenate the patient during the procedure.[1]

5.2 The danger of a serious complication from bronchoscopy is especially high in patients with the disorders listed, and these conditions are usually considered absolute contraindications unless the risk-benefit assessment warrants the procedure:[1,2]

5.2.1 Coagulopathy or bleeding diathesis that cannot be corrected,[1,2]

5.2.2 Severe obstructive airways disease,[1,2]

5.2.3 Severe refractory hypoxemia,[1,2]

5.2.4 Unstable hemodynamic status including dysrhythmias.[1,2]

5.3 Relative contraindications (or conditions involving increased risk), according to the American Thoracic Society Guidelines for Fiberoptic Bronchoscopy in adults,[1] include

5.3.1 Lack of patient cooperation;

5.3.2 Recent myocardial infarction or unstable angina;

5.3.3 Partial tracheal obstruction;

5.3.4 Moderate-to-severe hypoxemia or any degree of hypercarbia;

5.3.5 Uremia and pulmonary hypertension (possible serious hemorrhage after biopsy);

5.3.6 Lung abscess (danger of flooding the airway with purulent material);

5.3.7 Obstruction of the superior vena cava (possibility of bleeding and laryngeal edema);

5.3.8 Debility, advanced age, and malnutrition;

5.3.9 Respiratory failure requiring mechanical ventilation;

5.3.10 Disorders requiring laser therapy, biopsy of lesions obstructing large airways, or multiple transbronchial lung biopsies;

5.3.11 Known or suspected pregnancy because of radiation exposure.

5.4 The safety of bronchoscopic procedures in asthmatic patients is a concern, but the presence of asthma does not preclude the use of these procedures.[7,10]

FBA 6.0 HAZARDS/COMPLICATIONS:

6.1 Adverse effects of medication used before and during the bronchoscopic procedure[2,5,11,12]

6.2 Hypoxemia[2,13]

6.3 Hypercarbia

6.4 Wheezing[14]

6.5 Hypotension[14]

6.6 Laryngospasm, bradycardia, or other vagally mediated phenomena[2,5,11]

6.7 Mechanical complications such as epistaxis, pneumothorax, and hemoptysis[5,11,15]

6.8 Increased airway resistance[2,16]

6.9 Death[17]

6.10 Infection hazard for healthcare workers or other patients[18-21] (see also Section 13)

6.11 Cross-contamination of specimens or bronchoscopes[18-21]

FBA 7.0 LIMITATIONS/VALIDATION OF RESULTS:

7.1 Bronchoscopy should not be performed in patients who have a contraindication listed in Section 5.0 of this Guideline, unless the potential benefit outweighs the risk, as determined by the physician bronchoscopist.

7.2 Poor or inadequate training of the bronchoscopy assistant in

7.2.1 The techniques of premedication for bronchoscopic examination

7.2.2 Function and preparation of bronchoscope and related equipment

7.2.3 Physical and physiologic monitoring during the procedure

7.2.4 Specimen retrieval (biopsies and washings), preparation of specimens, and site documentation

7.2.5 Postprocedure care of the patient

FBA 8.0 ASSESSMENT OF NEED:

Need is determined by the presence of clinical indicators as previously described in Section 4.0, and by the presence of contraindications as described in Section 5.0.

FBA 9.0 ASSESSMENT OF OUTCOME:

Patient outcome is determined by clinical, physiologic, and pathologic assessment. Procedural outcome is determined by the accomplishment of the procedural goals as indicated in Section 4.0, and by quality assessment indicators listed in Section 11.0.

FBA 10.0 RESOURCES:

10.1 Equipment

10.1.1 Bronchoscopic devices

10.1.1.1 The appropriate scope size is determined by the bronchoscopist, based on the patient and procedures to be performed.[5]

10.1.1.2 Bronchoscopic light source, and any related video or photographic equipment, if applicable

10.1.1.3 Cytology brushes, flexible forceps, transbronchial aspiration needles, retrieval baskets (Compatibility of the external diameter of all scope accessories with the internal diameter of the bronchoscope should be verified before the procedure.)

10.1.1.4 Specimen-collection devices and fixatives (as determined by institutional policies)

10.1.1.5 Syringes for bronchoalveolar lavage, needle aspiration, and drug delivery

10.1.1.6 Bite block

10.1.1.7 Laryngoscope

10.1.1.8 Endotracheal tubes in various sizes

10.1.1.9 Thoracostomy set/tray

10.1.1.10 Venous access equipment (I.V. supplies)

10.1.2 Monitoring Devices

10.1.2.1 Pulse oximeter

10.1.2.2 Electrocardiographic monitoring equipment

10.1.2.3 Sphygmomanometer

10.1.2.4 Whole-body radiation badge for personnel

10.1.3 Procedure Room Equipment

10.1.3.1 Oxygen and related delivery equipment

10.1.3.2 Resuscitation equipment

10.1.3.3 Medical vacuum systems (wall or portable) and related suction supplies for scope or mouth

10.1.3.4 Infection control devices as listed in Section 13.0

10.1.3.5 Fluoroscopy equipment including personal protection

10.1.3.6 Laser equipment if applicable

10.1.3.7 Protease enzymatic agent (eg, Protozyme) for cleaning and removal of blood and protein before disinfection or sterilization, or other detergent capable of removing these substances[22]

10.1.3.8 High-level disinfection or sterilization agent: 2% alkaline glutaraldehyde (eg, Cidex, Sonacide, Glutarex), ethylene oxide,[20,23] or peracetic acid[24]

10.1.3.9 Adequate ventilation and other measures to prevent transmission of tuberculosis[25]

10.2 Medications: Institutional policies and personal preferences of the bronchoscopist vary greatly regarding the type and method of premedication for bronchoscopic examination. Administration of these medications by intravenous or intramuscular routes is limited to nurses, physicians, or other trained personnel. (The training and certification of "other personnel" is institution specific, should be consistent with institutional policies, and may include the respiratory therapist.) Aerosolized or atomized drugs, or drugs instilled through the bronchoscope, may be delivered by the respiratory therapist or other trained assistants.

10.2.1 Topical anesthetic (lidocaine 1%, 2%, 4%)[3,5,26,27]

10.2.2 Anticholinergic agent to reduce secretions and minimize vaso-vagal reflexes (atropine, glycopyrrolate)[3,26]

10.2.3 Sedative agent 30-45 min prior to the procedure (eg, codeine, meperidine, midazolam, morphine, hydroxyzine)[3,26]

10.2.4 Intravenous sedative immediately prior to and/or during the procedure (midazolam, diazepam, meperidine, fentanyl)[3,5,26]

10.2.5 Benzodiazepine antagonist (flumazenil),[2] narcotic antagonist (Narcan)

10.2.6 Sterile nonbacteriostatic physiologic (isotonic) saline solution[13]

10.2.7 Vasoconstrictor for bleeding control (dilute epinephrine, usually 1:10,000)[28,29]

10.2.8 Inhaled beta agonist (albuterol, metaproterenol)[27]

10.2.9 Water-soluble lubricant, or combined lubricant/anesthetic (viscous lidocaine)[5,23,26]

10.2.10 Emergency and resuscitation drugs as deemed appropriate by institutional policies

10.3 Personnel: The precise role of the bronchoscopy assistant varies among institutions;[2,3,5,30] however, the prime responsibilities include preparation and monitoring of the patient, assisting with the procedure, handling specimens, postprocedure care of the patient, maintenance of the bronchoscopy equipment, and recordkeeping.

10.3.1 Bronchoscopy assisting should occur only under the direction of a physician who has been trained in bronchoscopy according to the Guidelines endorsed by the American Thoracic Society.[1,2]

10.3.2 Bronchoscopy assisting should be limited to Level II personnel who possess the skills necessary to determine adverse reactions and to undertake the appropriate remedial action.

10.3.3 The bronchoscopy assistant must be trained in the setup, handling, cleaning, and care of bronchoscopy equipment and related supplies; specimen retrieval and preparation for commonly ordered laboratory studies on bronchoscopy specimens; biopsy labeling; delivery of aerosolized drugs; and mechanical ventilation. The assistant must also be trained in monitoring and evaluating the patient's clinical condition as reflected by pulse oximetry, electrocardiogram, and stability of or changes in mechanical ventilation parameters, and be capable of relating changes in clinical condition to disease state, procedure, or drugs administered for the procedure. Assistants should be versed in CDC ventilation requirements for control of tuberculosis transmission. Bronchoscopy assistants should hold one of the following credentials: Certified Respiratory Therapy Technician (CRTT), Registered Respiratory Therapist (RRT), Certified Pulmonary Function Technologist (CPFT), Registered Pulmonary Function Technologist (RPFT), Registered Nurse (RN), Licensed Practical Nurse (LPN), physician (MD or DO), or operating room technician.

FBA 11.0 MONITORING:

The following should be monitored before, during, and/or after bronchoscopy, continuously, until the patient returns to his pre-sedation level of consciousness.

11.1 Patient

11.1.1 Level of consciousness[30]

11.1.2 Medications administered, dosage, route, and time of delivery[30]

11.1.3 Subjective response to procedure (eg, pain, discomfort, dyspnea)[30]

11.1.4 Blood pressure, heart rate, rhythm, and changes in cardiac status

11.1.5 S_{pO_2} and F_{IO_2}[30,31]

11.1.6 Tidal volume, peak inspiratory pressure, adequacy of inspiratory flow, and other ventilation parameters if subject is being mechanically ventilated

11.1.7 Lavage volumes (delivered and retrieved)

11.1.8 Documentation of site of biopsies and washings and tests requested on each sample

11.1.9 Periodic postprocedure follow-up monitoring of patient condition is advisable for 24-48 hours for inpatients. Outpatients should be instructed to contact the bronchoscopist regarding fever, chest pain or discomfort, dyspnea, wheezing, hemoptysis, or any new findings presenting after the procedure has been completed. Oral instructions should be reinforced by written instructions that include names and phone numbers of persons to be contacted in emergency.

11.2 Technical Devices

11.2.1 Bronchoscope integrity (fiberoptic or channel damage, passage of leak test)[23]

11.2.2 Strict adherence to the recommended procedures for cleaning, disinfection, and sterilization of the devices, and the integrity of disinfection or sterilization packaging[22,23]

11.2.3 Smooth, unhampered operation of biopsy devices (forceps, needles)

11.3 Recordkeeping

11.3.1 Quality assessment indicators as determined appropriate by the institution's quality assessment committee

11.3.2 Documentation of monitors indicated in Sections 11.1 and 11.2.

11.3.3 Identification of bronchoscope used for each patient

11.3.4 Annual assessment of the institutional or departmental bronchoscopy procedure, including an evaluation of

11.3.4.1 adequacy of bronchoscopic specimens (size or volume for accurate analysis, sample integrity)

11.3.4.2 review of infection control procedures and compliance with the current guidelines for semicritical patient-care objects[22,25]

11.3.4.3 synopsis of complications

11.3.4.4 control washings to assure that infection control and disinfection/sterilization procedures are adequate, and that cross-contamination of specimens does not occur

11.3.4.5 annual review of the bronchoscopy service and all of the above listed records with the physician bronchoscopists

FBA 12.0 FREQUENCY:

The frequency with which bronchoscopy is repeated on a given patient should be determined by the physician bronchoscopist based on indications.

FBA 13.0 INFECTION CONTROL:

13.1 Universal Precautions[32,33]

13.2 CDC Guideline for Handwashing and Hospital Environmental Control—Section 2: Cleaning, disinfecting, and sterilizing patient care equipment[22]

13.3 CDC Guideline for preventing tuberculosis transmission[25]

13.4 Hepatitis B vaccination for personnel

13.5 Establishment of and conformance to written protocol for infection control.

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AARC Clinical Practice Guideline

Resuscitation in Acute Care Hospitals

RACH 1.0 PROCEDURE:

Recognition of signs suggesting the possibility or the presence of cardiopulmonary arrest and initiation of resuscitation and life-support measures, in adults, children, and infants.

RACH 2.0 DESCRIPTION/DEFINITION:

Resuscitation in acute care hospitals (RACH) for the purpose of this guideline encompasses all care necessary to deal with sudden and often life-threatening events affecting the cardiopulmonary system, and involves the identification, assessment, and treatment of patients in danger of or in frank arrest, including the high-risk delivery patient. This includes (1) alerting the resuscitation team and the managing physician; (2) using adjunctive equipment and special techniques for establishing, maintaining, and monitoring effective ventilation and circulation; (3) monitoring the electrocardiograph and recognizing dysrhythmias; (4) using defibrillators and mechanical ventilators; (5) administering oxygen and drugs, including instillation of drugs via the endotracheal tube; and (6) stabilizing such patients in the postarrest period.

RACH 3.0 SETTING:

The Guideline applies to resuscitation efforts in the acute care hospital and during interhospital transport.

RACH 4.0 INDICATIONS:

Cardiac arrest, respiratory arrest, or the presence of conditions that may lead to cardiopulmonary arrest as indicated by rapid deterioration in vital signs, level of consciousness, and blood gas values—included in those conditions are

4.1 Airway obstruction—partial or complete
4.2 Acute myocardial infarction with cardiodynamic instability
4.3 Life-threatening dysrhythmias
4.4 Hypovolemic shock
4.5 Severe infections
4.6 Spinal cord or head injury
4.7 Drug overdose
4.8 Pulmonary edema
4.9 Anaphylaxis
4.10 Pulmonary embolus
4.11 Smoke inhalation
4.12 High-risk delivery

RACH 5.0 CONTRAINDICATIONS:

Resuscitation is contraindicated when

5.1 the patient's desire not to be resuscitated has been clearly expressed and documented in the patient's medical record,[1-3]
5.2 resuscitation has been determined to be futile because of the patient's underlying condition or disease. [4-9]

RACH 6.0 PRECAUTIONS/HAZARDS AND/OR COMPLICATIONS:

The following represent possible hazards or complications related to the major facets of resuscitation:

6.1 Airway management[10,11]
  6.1.1 Failure to establish a patent airway[12]
  6.1.2 Failure to intubate the trachea[12]
  6.1.3 Failure to recognize intubation of the esophagus[12]
  6.1.4 Upper airway trauma, laryngeal and esophageal damage[13-17]
  6.1.5 Aspiration[12,13,18,19]
  6.1.6 Cervical spine trauma[10,13]

  - **6.1.7** Unrecognized bronchial intubation[18,20]
  - **6.1.8** Eye injury[10]
  - **6.1.9** Facial trauma[18]
  - **6.1.10** Problems with ETT cuff[21]
  - **6.1.11** Bronchospasm[10]
  - **6.1.12** Laryngospasm[10]
  - **6.1.13** Dental accidents[13,18]
  - **6.1.14** Dysrhythmias[22]
  - **6.1.15** Hypotension and bradycardia due to vagal stimulation[10,23]
  - **6.1.16** Hypertension and tachycardia
  - **6.1.17** Inappropriate tube size[18,21]
- **6.2** Ventilation
  - **6.2.1** Inadequate oxygen delivery (F_{DO_2})[24-27]
  - **6.2.2** Hypo- and/or hyperventilation[28-30]
  - **6.2.3** Gastric insufflation and/or rupture[12,31]
  - **6.2.4** Barotrauma[32-34]
  - **6.2.5** Hypotension due to reduced venous return secondary to high mean intrathoracic pressure [35,36]
  - **6.2.6** Vomiting and aspiration [12]
  - **6.2.7** Prolonged interruption of ventilation for intubation[37,38]
  - **6.2.8** Failure to establish adequate functional residual capacity in the newborn[39-41]
- **6.3** Circulation
  - **6.3.1** Ineffective chest compression[42,43]
  - **6.3.2** Fractured ribs and/or sternum[12,13,44,45]
  - **6.3.3** Laceration of spleen or liver[12,13,44-49]
  - **6.3.4** Failure to restore circulation despite functional rhythm
    - **6.3.4.1** Severe hypovolemia[50,51]
    - **6.3.4.2** Cardiac tamponade[51]
    - **6.3.4.3** Hemo- or pneumothorax[50,51]
    - **6.3.4.4** Hypoxia
    - **6.3.4.5** Acidosis
    - **6.3.4.6** Hyperkalemia
    - **6.3.4.7** Massive acute myocardial infarction[50]
    - **6.3.4.8** Hypothermia (in neonates[52,53] and children[38])
    - **6.3.4.9** Aortic dissection[50]
    - **6.3.4.10** Air embolus, pulmonary embolism[50]
- **6.4** Electrical therapy
  - **6.4.1** Failure of defibrillator[54]
  - **6.4.2** Shock to team members[55]
  - **6.4.3** Inappropriate countershock
    - **6.4.3.1** Muscle burn[56,57]
    - **6.4.3.2** Infantile hematomyelia[58]
  - **6.4.4** Induction of malignant dysrhythmias[59,60]
  - **6.4.5** Interference with implanted pacemaker function[61]
  - **6.4.6** Fire hazard[62]
- **6.5** Drug administration
  - **6.5.1** Inappropriate drug or dose
  - **6.5.2** Idiosyncratic or allergic response to drug
  - **6.5.3** Endotracheal-tube drug-delivery failure[63-65]—The endotracheal tube dose should be 2 to 2.5 times the normal I.V. or intraosseous dose, diluted in 10 mL of normal saline (or distilled water). The drug should be instilled via endobronchial catheter to assure distribution beyond central airways.

RACH 7.0 LIMITATIONS OF PROCEDURE:

Despite adequate efforts, resuscitation may fail because of the patient's underlying disease. Institution of resuscitation may be limited by patient or surrogate/guardian request.[1-3]

RACH 8.0 ASSESSMENT OF NEED:

- **8.1** Assessment of patient condition
  - **8.1.1** Prearrest—Identification of patients (including the fetus) in danger of imminent arrest and in whom consequent early intervention may prevent arrest and improve outcome. These are patients with conditions that may lead to cardiopulmonary arrest as indicated by rapid deterioration in vital signs, level of consciousness, blood gas values, or fetal monitoring data (see Section 4.00).
  - **8.1.2** Arrest—absence of spontaneous breathing and/or circulation
  - **8.1.3** Postarrest—Once a patient has sustained an arrest, the likelihood of additional life-threatening problems is high and continued vigilance and aggressive action using this Guideline are indicated. Control of the airway and cardiac monitoring must be continued and optimal oxygenation and ventilation assured.

RACH 9.0 ASSESSMENT OF PROCESS AND OUTCOME:

9.1 Timely, high-quality resuscitation improves patient outcome in terms of survival and level of function. Despite optimal resuscitation performance, outcomes are affected by patient-specific factors. Patient condition postarrest should be evaluated from this perspective.

9.2 Documentation and evaluation of the resuscitation process (eg, system activation, team member performance, functioning of equipment, and adherence to guidelines and algorithms) should occur continuously and improvements be made.[66-70]

RACH 10.0 RESOURCES:

10.1 Emergency response system—A designated resuscitation team should be continuously available (24 hours/day, 7 days/week) to respond to emergencies.[70] Specialty resuscitation teams trained to meet the needs of different hospital populations are desirable (eg, trauma, stroke, neonatal). Team members should be notified simultaneously. All hospital workers must know how to activate the hospital's emergency response system.

10.2 Equipment should be rapidly available and functional. Durability, portability, reliability, and cost should be considered.

- **10.2.1** Ventilation devices
  - **10.2.1.1** Mouth-to-mask devices must
    - **10.2.1.1.1** provide a way to increase F_{DO_2};[71-78]
    - **10.2.1.1.2** separate inhaled and exhaled gas;[71-78]
    - **10.2.1.1.3** incorporate an effective filter;[71-78]
    - **10.2.1.1.4** be transparent;[71-78]
    - **10.2.1.1.5** easily achieve an airtight seal;[71-78]
    - **10.2.1.1.6** have extension tube to facilitate visual monitoring and ventilation;[71-78]
    - **10.2.1.1.7** have dead space as low as practical.[71-78]
  - **10.2.1.2** Manual resuscitators must
    - **10.2.1.2.1** be capable of providing an F_{DO_2} of 1.0 even when large volumes are delivered;[24,25,29,79-82]
    - **10.2.1.2.2** have no pressure-relief valve for adults and children; infant devices must incorporate an in-line manometer;[81]
    - **10.2.1.2.3** have a bag volume of approximately 1,600 mL for adults and children, and approximately 500 mL for infants;
    - **10.2.1.2.4** have minimal forward and back leak;[25,38,82]
    - **10.2.1.2.5** have standard 15- and 22-mm fitting;[82,83]
    - **10.2.1.2.6** be impossible to misassemble;
    - **10.2.1.2.7** be easily sterilized or for single-patient use;
    - **10.2.1.2.8** provide for measurement of exhaled tidal volume;[66,67]
    - **10.2.1.2.9** provide some indication that supplemental oxygen is being supplied (easily ascertained with bag reservoir but difficult with tube-type reservoir);
    - **10.2.1.2.10** be capable of being restored to proper function after being disabled with vomitus;[25,26,29]
    - **10.2.1.2.11** be able to be restored to proper function after being dropped from a height of 1 meter onto concrete floor;
    - **10.2.1.2.12** be designed so that pressure generated at the patient connection port is less than 5 cm H_2O during exhalation (at a flow of 5 L/min for patients weighing < 10 kg and 50 L/min for all others);[84,85]
    - **10.2.1.2.13** be designed so that pressure generated at the patient connection port does not exceed -5 cm H_2O during inspiration (at a flow of 5 L/min for patients weighing < 10 kg and 50 L/min for all others);[84,85]
    - **10.2.1.2.14** be capable of providing a high F_{DO_2} during spontaneous breathing with low inspiratory and expiratory resistance (see above).[84,85]

10.2.1.3 Face-mask design should allow a tight seal, provide minimal internal dead space, and have a clear mask body. A variety of sizes should be available.[72-74,86]

10.2.1.4 Non-self-inflating bags vary in size from 500-2,000 mL, are inflated by a controlled gas source, have variable flow outlets, and conform to the same standards listed in 10.2.1.2 (where appropriate). For infant application, a manometer should be used. The operation of this device should be limited to personnel who have received sufficient training and who use it routinely.[87]

10.2.1.5 Gas-powered resuscitators (manually triggered, commonly called demand valves) are not recommended.[24,80,88-93]

10.2.1.6 Transport ventilators are recommended for resuscitation if they provide control over tidal volume, inspiratory time, and inspiratory flow, and deliver F_{DO_2} of 1.0.[94,95]

10.2.1.7 The continued use of the mechanical ventilator is indicated when a patient already being mechanically ventilated is resuscitated if the ventilator provides control over tidal volume, inspiratory time, and flow; can be manually triggered; and delivers an F_{DO_2} of 1.0. During CPR in infants, manual ventilation is preferred.

10.2.2 Circulation devices

10.2.2.1 Manually operated mechanical chest compressors are appropriate for adults and adolescents.[38:2204,96-98] They must be capable of providing an adjustable stroke of 1.5 to 2 in (3.8 to 5.1 cm), deliver the compression for 50% of the compression-relaxation cycle, and should be placed in use with only brief interruption of manual CPR. The compressor head should be designed to limit shift in position, and stroke adjustment and should have a locking mechanism. The device must be portable, stored easily, and assembled quickly.

10.2.2.2 Automatic mechanical chest compressors are appropriate for adults and adolescents and should have the capabilities of the manual devices plus the advantage of delivering optimal rate and depth of compression by eliminating the variables of operator technique and fatigue.[38:2204] The device should allow ECG recording, and defibrillation should not require that the device be stopped or removed.[38:2204] It is not recommended that these devices be used for ventilation unless a cuffed endotracheal tube is in place.[38:2204,96-98]

10.2.3 Airway management devices

10.2.3.1 Oropharyngeal airways should be available in a variety of sizes for adults, children, and infants. Design should incorporate a flange, a short biteblock segment, and a curved body containing a channel for air movement and suctioning.[99]

10.2.3.2 Nasopharyngeal airways should be available in a variety of sizes for adults, children, and infants. They consist of a soft rubber or plastic tube with a beveled tip and a flange that preferably is adjustable.

10.2.3.3 Endotracheal tubes should be available in a variety of sizes for infants, children, and adults. Sizes less than 2.5 mm O.D. are not recommended, and uncuffed tubes should be used in children < 8 years of age. Tubes should meet ASTM standards.[99]

10.2.3.4 Intubation devices facilitate intubation and access to the difficult airway. Such devices may include laryngoscope and blades (straight & curved), wire guide/stylet, forceps, fiberoptic laryngoscope or bronchoscope, "light wand," or tube changing stent.[86,100]

10.2.3.5 Tube stabilization should be reliable and effective and allow for atraumatic extubation and reintubation when necessary.

10.2.3.6 Suctioning devices should be capable of subatmospheric pressure levels of 0 to −300 torr (occluded) and should allow an unrestricted flow of 30

L/min.[38:2203] A portable system should be available for transport. A variety of rigid pharyngeal tips and a variety of sizes of sterile tracheal catheters should be available. The tracheal suction catheter selected should have an outside diameter of less than one half the inside diameter of the endotracheal (or tracheostomy) tube and have a means of manual control (thumb port).

10.2.4 Electrical therapy devices

10.2.4.1 Defibrillators

10.2.4.1.1 Manual defibrillators depend upon operator for analysis of rhythm, charging, proper application of paddles to patient's thorax, and delivery of counter-shock; use of self-adhesive pads may increase efficacy and speed of counter-shock.[101,102]

10.2.4.1.2 Semiautomatic/automatic defibrillators utilize large, self-adhesive pads to optimize electrical contact with the patient's thorax and allow delivery of countershock more rapidly than manual defibrillators.[54,102] Automatic defibrillators, when attached to patient, analyze rhythm and deliver countershock when appropriate without intervention by operator; semiautomatic defibrillators require pressing a button to initiate rhythm analysis and advise operator when delivery of counter-shock (by pressing a button) is appropriate.[103-106]

10.2.4.1.3 External pacemakers allow noninvasive cardiac pacing via large, self-adhesive pads, in cases of bradycardia with a pulse or high-grade block when a conducted beat results in a pulse.[106-109]

10.2.5 Monitoring devices

10.2.5.1 ECG monitors—Continuous electrocardiographic monitoring is essential for detection of dysrhythmias and for directing therapy.

10.2.5.2 CO_2 monitors—CO_2 detectors are useful for identification of correct endotracheal tube placement and for monitoring of cardiac function during resuscitation.[110-114]

10.2.5.3 Ventilation monitors—Because artificial ventilation, either manual or mechanical, is often inconsistent during resuscitation, monitoring of exhaled volume is recommended.[66,67]

10.2.5.4 Pulse oximeters—Pulse oximeters, if used in the pre- and postarrest situation, may provide useful information regarding oxygenation and cardiovascular performance in adults and adolescents. Those that display pulse waveform are preferred. The use of oximeters during delivery room resuscitation of infants is recommended.[115]

10.2.5.5 Invasive hemodynamic monitoring devices—Continuous monitoring of intravascular waveforms and pressures provides useful information for diagnosis and treatment of cardiovascular compromise.

10.2.5.6 Airway pressure monitoring is useful in adults and is essential in small children and infants.[116-118]

10.3 Personnel: All hospital workers must recognize the need for and know how to activate the hospital's emergency response system. All health professionals should be trained, evaluated at frequent intervals by monitoring performance, and retrained as necessary in the skills of basic life support (BLS). Health professionals who are primary members of resuscitation teams in acute care hospitals should be skilled in emergency cardiac care (ECC) and advanced cardiac life support (ACLS).[38,113-123]

10.3.1 Level I[119-123]

10.3.1.1 Training—all Level I personnel should be trained, evaluated by performance, and retrained as necessary in BLS at frequent intervals that do not exceed one year. Retraining should focus on identified deficiencies.

10.3.1.2 Responsibilities—Level I personnel are health professionals who assist the primary (Level II) members of the resuscitation team. They should be capable of assisting Level II personnel by (1) assessing patients for respiratory and/or cardiac arrest, (2) activating the resuscitation team, (3) administering BLS, (4) providing mouth-to-mask ventilation, (5) attaching ECG and automatic defibrillator electrodes, (6) assisting with tracheal intubation, (7) defibrillating with automatic electronic defibrillators, (8) attaching pulse oximeter and capnograph, (9) preparing a written record of resuscitation effort, (10) moving resuscitation equipment to the scene, and (11) collecting arterial blood for analysis.

10.3.1.3 Credentials—Level I health professionals should hold one or more of the following credentials: RRT, CRTT, RN, or MD; and have current BLS healthcare provider course completion card from the American Heart Association. Health professionals and hospital personnel not holding one of these Level I credentials should at a minimum be capable of assessing the patient for respiratory and/or cardiac arrest, activating the resuscitation team, and administering BLS until the team arrives.

10.3.2 Level II[119]

10.3.2.1 Training—Level II personnel should be trained, evaluated by performance, and retrained as necessary in ECC and ACLS or pediatric advanced life support (PALS) and/or neonatal resuscitation program (NRP) as appropriate at intervals that should not exceed one year. Retraining should focus on identified deficiencies.

10.3.2.2 Responsibilities—Level II health professionals should be capable of serving as primary members of the resuscitation team and as team leader when they are the best qualified respondent. They may respond not only to resuscitation calls in their work areas but also to other areas of the hospital. They are skilled in the use of all adjunctive equipment and special techniques for ECC/ACLS (eg, establishing, maintaining, and monitoring effective ventilation and circulation). They have the skills of Level I personnel and the following capabilities: (1) advanced ECG monitoring and dysrhythmia recognition, (2) tracheal intubation, (3) defibrillation and cardio-version with nonautomatic electronic defibrillators, (4) use of continuous and transport mechanical ventilators, (5) use of manual or automatic external chest compressors, (6) preparation and administration of cardiac drugs, (7) stabilization of patients in the postarrest period, (8) provision of access for rapid administration of intravenous fluids, (9) managing ventilation via transtracheal catheter and cricothyrotomy, (10) emergency treatment of tension pneumo- or hemothorax with large bore needle, (11) interpretation of hemodynamic data (12) preparing patients for emergency transport, and (13) evaluating oxygenation, ventilation and acid-base balance from blood gas reports.

10.3.2.3 Credentials—Level II health professionals should hold one or more of the following credentials: RRT, RN, or MD; and current ACLS, PALS, and/or NRP course completion card as appropriate from the American Heart Association.

RACH 11.0 MONITORING:

11.1 Patient

11.1.1 Clinical assessment—continuous observation of the patient and repeated clinical assessment by a trained observer provide optimal monitoring of the resuscitation process. Special consideration should be given to the following:

11.1.1.1 Level of consciousness

11.1.1.2 Adequacy of airway

11.1.1.3 Adequacy of ventilation

11.1.1.4 Peripheral/apical pulse and character

11.1.1.5 Evidence of chest and head trauma

11.1.1.6 Pulmonary compliance and airway resistance

11.1.1.7 Presence of seizure activity

11.1.2 Assessment of physiologic parameters—Repeat assessment of physiologic data by trained professionals supplements clinical assessment in managing patients throughout the resuscitation process. Monitoring devices should be available, accessible, functional, and periodically evaluated for function. These data include but are not limited to[66]

11.1.2.1 Arterial blood gas studies (although investigators have suggested that such values may have a limited role in decision making during CPR[124])

11.1.2.2 Hemodynamic data[119,125-127]

11.1.2.3 Cardiac rhythm[38:2236,120,121]

11.1.2.4 Ventilatory frequency, tidal volume, and airway pressure[66,67,87]

11.1.2.5 Exhaled CO_2[110-114]

11.1.2.6 Neurologic status

11.2 Resuscitation process—properly performed resuscitation should improve patient outcome. Continuous monitoring of the process will identify areas needing improvement. Among these areas are response time, equipment function, equipment availability, team member performance, team performance, complication rate, and patient survival and functional status.

RACH 12.0 FREQUENCY/AVAILABILITY/ DURATION:

Because the need for resuscitation occurs unpredictably, resources need to be available to respond to one or more locations simultaneously 24 hours a day, 7 days a week. BLS response should be available within 3 minutes and ACLS within ≤ 8 minutes. A person capable of performing resuscitation should be present at every infant delivery.[128] Resuscitation continues until vital signs are restored. If vital signs are not restored, resuscitation efforts should continue until a physician decides further efforts are futile.

RACH 13.0 INFECTION CONTROL:

13.1 Implement Universal Precautions,[129] including mouth-to-barrier devices.[38:2197]

13.2 Observe all infection control guidelines posted for patient.

13.3 Disinfect all equipment to be reused on other patients.

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AARC Clinical Practice Guideline

Intermittent Positive Pressure Breathing

IPPB 1.0 PROCEDURE:

Intermittent positive pressure breathing

IPPB 2.0 DESCRIPTION/DEFINITION:

IPPB is a technique used to provide short-term or intermittent mechanical ventilation for the purpose of augmenting lung expansion, delivering aerosol medication, or assisting ventilation.[1]

2.1 IPPB is not a therapy of first choice for aerosol delivery or lung expansion in spontaneously breathing patients when other less expensive and less invasive therapies can reliably meet clinical objectives.[2-8]
2.2 IPPB can include volume-, pressure-, time-limited, or flow-cycled ventilation.
2.3 IPPB may be applied to intubated as well as nonintubated patients.

IPPB 3.0 SETTINGS:

IPPB can be administered in settings that include hospital, clinic, extended care facility, and home.

IPPB 4.0 INDICATIONS:

4.1 The need to improve lung expansion
4.1.1 The presence of clinically important pulmonary atelectasis when other forms of therapy have been unsuccessful (incentive spirometry, chest physiotherapy, deep breathing exercises, positive airway pressure) or the patient cannot cooperate[9-14]
4.1.2 Inability to clear secretions adequately because of pathology that severely limits the ability to ventilate or cough effectively and failure to respond to other modes of treatment[13]
4.2 The need for short-term ventilatory support for patients for are hypoventilated as an alternative to tracheal intubation and continuous ventilatory support[12-21]
4.3 The need to deliver aerosol medication (We are not addressing aerosol delivery for patients on long-term mechanical ventilation)[4]
4.3.1 Although some authors oppose the use of IPPB in the treatment of severe bronchospasm (acute asthma, unstable or status asthmaticus, exacerbated COPD),[6,22-24] we recommend a careful, closely supervised trial of IPPB when treatment using other techniques (metered dose inhaler [MDI] or nebulizer) has been unsuccessful.[1,25-33]
4.3.2 IPPB may be used to deliver aerosol medications to patients with fatigue as a result of ventilatory muscle weakness (eg, failure to wean from mechanical ventilation, neuromuscular disease, kyphoscoliosis) or chronic conditions in which intermittent ventilatory support is indicated (eg, ventilatory support for home care patients and the more recent use of nasal IPPV for respiratory insufficiency).[1,15-21]

IPPB 5.0 CONTRAINDICATIONS:

Although no absolute contraindications to the use of IPPB therapy (except the oft-cited tension pneumothorax) have been reported, the patient with any of the following should be carefully evaluated before a decision is made to initiate IPPB therapy.

5.1 Intracranial pressure (ICP) > 15 mm Hg
5.2 Hemodynamic instability
5.3 Recent facial, oral, or skull surgery
5.4 Tracheoesophageal fistula

5.5 Recent esophageal surgery
5.6 Active hemoptysis
5.7 Nausea
5.8 Air swallowing
5.9 Active untreated tuberculosis
5.10 Radiographic evidence of bleb
5.11 Singulation (hiccups)

IPPB 6.0 HAZARDS/COMPLICATIONS:

6.1 Increased airway resistance[34]
6.2 Barotrauma, pneumothorax[34]
6.3 Nosocomial infection[34]
6.4 Hypocarbia[4,35]
6.5 Hemoptysis[4,35]
6.6 Hyperoxia when oxygen is the gas source[34]
6.7 Gastric distention[34]
6.8 Impaction of secretions (associated with inadequately humidified gas mixture)[34]
6.9 Psychological dependence[34]
6.10 Impedance of venous return[34]
6.11 Exacerbation of hypoxemia
6.12 Hypoventilation
6.13 Increased mismatch of ventilation and perfusion
6.14 Air trapping, auto-PEEP, overdistended alveoli

IPPB 7.0 LIMITATIONS OF PROCEDURE OR DEVICE:

7.1 All of the mechanical effects of IPPB are short-lived—lasting ≤ an hour after treatment.[35,36]
7.2 Based on the available literature, MDI or compressor-driven nebulizers should be considered the devices of choice for aerosol therapy to COPD and stable asthma patients.[1,3-8]
7.3 Only a very small percentage of the aerosol output deposits in the airway.[37] Delivery of a therapeutic dose via IPPB may require as much as a tenfold increase in medication amount over MDI.[38,39]
7.4 Efficacy of device for ventilation and aerosol delivery is technique dependent (eg, coordination, breathing pattern, selection of appropriate inspiratory flow, peak pressure, inspiratory hold).[40-51]
7.5 Efficacy is dependent on the design of the device (eg, flow, volume, and pressure capability as well as aerosol output and particle size).[40,42,52-54]
7.6 IPPB is equipment- and labor-intensive as a method of delivery of aerosol.[40,42,55-59]
7.7 Limited portability and lack of convenience may affect patient compliance.

IPPB 8.0 ASSESSMENT OF NEED:

8.1 Presence of atelectasis
8.2 Reduced pulmonary function as evidenced by reductions in timed volumes, and vital capacity (eg, $FEV_1 < 65\%$ predicted, $FVC < 70\%$ predicted, $MVV < 50\%$ predicted,[60] or $VC < 10$ mL/kg) precluding an effective cough
8.3 Neuromuscular disorders or kyphoscoliosis with associated decreases in lung volumes and capacities
8.4 Fatigue or muscle weakness with impending respiratory failure
8.5 Presence of acute severe bronchospasm or exacerbated COPD that fails to respond to other therapy
  8.5.1 Regardless of the type of delivery device used (MDI with spacer or small volume, large-volume, or ultrasonic nebulizer), it is important to recognize that the dose of the drug needs to be titrated to give the maximum benefit.[37,39]
  8.5.2 Based on proven therapeutic efficacy, variety of medications, and cost-effectiveness, the MDI with accessory device should be the first method to consider for administration of aerosol.[42,55-59,61,62]
8.6 With demonstrated effectiveness, the patient's preference for a positive pressure device should be honored.

IPPB 9.0 ASSESSMENT OF OUTCOME:

9.1 Tidal volume during IPPB greater than during spontaneous breathing (by at least 25%)
9.2 FEV_1 or peak flow increase
9.3 Cough more effective with treatment
9.4 Secretion clearance enhanced as a consequence of deep breathing and coughing
9.5 Chest x-ray improved

9.6 Breath sounds improved
9.7 Favorable patient subjective response

IPPB 10.0 RESOURCES:

10.1 Equipment

10.1.1 IPPB device or pressure-support; volume-, pressure-, or time-limited ventilator or manual resuscitation device
10.1.2 Connecting tubing
10.1.3 Nebulizer (small-volume, large-volume, or ultrasonic) and medication or normal saline, or MDI with accessory adapter, or humidifier
10.1.4 Mouthpiece, flange (lip seal), nose clip, mask, or endotracheal tube adapter
10.1.5 Tissues and emesis basin or container for collecting or disposing of expectorated sputum
10.1.6 Gloves, goggles, gown, and mask as indicated
10.1.7 Hand-held spirometer or other volume-measuring device
10.1.8 Oral and/or endotracheal suction equipment

10.2 Personnel: A spectrum of education and skill levels is required for personnel who administer IPPB therapy. Different clinical situations warrant the degree of training necessary to provide optimal respiratory care:

10.2.1 Level I caregiver may be the provider of service after Level II personnel have established need for a specific device by patient assessment, and the first administration has been completed. Level I personnel must demonstrate

10.2.1.1 ability to prepare, measure, and mix medication;
10.2.1.2 proper technique for administration of medication;
10.2.1.3 proper use of equipment, including adjustment of machine settings to meet patient demands;
10.2.1.4 effective cleaning of equipment;
10.2.1.5 proper disposal of wastes;
10.2.1.6 ability to encourage effective breathing patterns and coughing techniques;
10.2.1.7 ability to modify technique (after communication with physician) in response to recognized complications and adverse reactions or change in severity of symptoms as determined by observation and vital-signs determination;
10.2.1.8 ability to implement Universal Precautions and proper infection control.

10.2.2 Level II Personnel must demonstrate all Level I skills and

10.2.2.1 ability to perform physical exam—auscultation, inspection, percussion, and vital signs;
10.2.2.2 ability to assess patient condition and patient response to therapy;
10.2.2.3 ability to perform peak expiratory flowrate, spirometry, and ventilatory mechanics measurement;
10.2.2.4 proper use and knowledge of limitations of IPPB equipment and aerosol device and ability to fit mask and/or identify best application device for particular patient;
10.2.2.5 ability to recognize and respond to therapeutic changes, adverse response, and complications of aerosol medications;
10.2.2.6 ability to modify dosage of medication and/or frequency of administration as prescribed in response to severity of symptoms;
10.2.2.7 ability to negotiate care plan and modifications with physician and healthcare team;
10.2.2.8 understanding of effects of increased pressure on ventilation, perfusion, and sputum mobilization;
10.2.2.9 ability to modify technique in response to adverse reactions;
10.2.2.10 ability to instruct patient/family/caregiver in goals of therapy and

10.2.2.10.1 proper technique for administration,
10.2.2.10.2 proper use of equipment,
10.2.2.10.3 cleaning of equipment,
10.2.2.10.4 breathing patterns and cough techniques,

10.2.2.10.5 recognition of communications and technique modification in response to adverse reactions,

10.2.2.10.6 frequency modification in response to severity of symptoms;

10.2.2.11 understanding and compliance with Universal Precautions and infection control issues related to cleaning and maintaining equipment and handling of secretions and hazardous waste.

10.2.3 Level III—Self-administration of IPPB. Patients who are to self-administer IPPB should demonstrate to the supervising clinician

10.2.3.1 proper technique for administration;

10.2.3.2 proper use of equipment;

10.2.3.3 proper cleaning of equipment;

10.2.3.4 ability to measure and mix medications;

10.2.3.5 breathing patterns and cough techniques;

10.2.3.6 technique modification in response to adverse reactions, duration or frequency modification in response to severity of symptoms.

IPPB 11.0 MONITORING:

Items from the following list should be chosen as appropriate for the specific patient.

11.1 Performance of machine trigger sensitivity, peak pressure, flow setting, F_{IO_2}, inspiratory time, expiratory time, plateau pressure, PEEP

11.2 Respiratory rate and volume

11.3 Peak flow or FEV_1/FVC

11.4 Pulse rate and rhythm from EKG if available

11.5 Patient subjective response to therapy—pain, discomfort, dyspnea

11.6 Sputum production—quantity, color, consistency, and odor

11.7 Mental function

11.8 Skin color

11.9 Breath sounds

11.10 Blood pressure

11.11 Arterial hemoglobin saturation by pulse oximetry (if hypoxemia is suspected)

11.12 Intracranial pressure (ICP) in patients for whom ICP is of critical importance

11.13 Chest radiograph

IPPB 12.0 FREQUENCY:

12.1 Critical care—q 1 h-q 6 h, for IPPB as tolerated. IPPB order should be re-evaluated at least every 24 hours based on assessments during individual treatments.

12.2 Acute/domiciliary care—

12.2.1 Common strategies for IPPB vary from *qid* to *bid*. Frequency should be determined by assessing patient response to therapy.

12.2.2 For acute care patients, order should be re-evaluated based on patient response to therapy at least every 72 hours or with any change of patient status.

12.2.3 Domiciliary patients should be re-evaluated periodically and with any change of status.

IPPB 13.0 INFECTION CONTROL:[42]

13.1 Caregivers should implement Universal Precautions[63] and appropriate guidelines for prevention of tuberculosis transmission.[64]

13.2 Caregivers should observe all infection control guidelines posted for patient.

13.3 All reusable equipment should be disinfected between patients.

13.4 Nebulizers should be changed or subjected to high-level disinfection

13.4.1 at conclusion of dose administration (for single treatment), or

13.4.2 every 24 hours with continuous administration, or more often when visibly soiled.

13.5 Nebulizers should not be rinsed with tap water between treatments,[65,66] but may be rinsed with sterile water or sterile saline and allowed to air dry.

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AARC Clinical Practice Guideline

Bland Aerosol Administration

BAA 1.0 PROCEDURE:

Bland aerosol administration

BAA 2.0 DESCRIPTION/DEFINITION:

For purposes of this guideline, bland aerosol administration includes the delivery of sterile water or hypotonic, isotonic, or hypertonic saline in aerosol form.[1] Bland aerosol administration may be accompanied by oxygen administration.

2.1 The use of cool, bland aerosol therapy is primarily indicated for upper airway administration;[1,2] therefore, a mass median aerodynamic diameter (MMAD) $\geq 5\ \mu$ is desirable.
2.2 The use of hypo- and hypertonic saline is primarily indicated for inducing sputum specimens; therefore, a MMAD of 1-5 μ is desirable.
2.3 The use of heated bland aerosol is indicated primarily for minimizing humidity deficit when the upper airway has been bypassed;[3] therefore, a MMAD of 2-10 μ is desirable.

BAA 3.0 SETTINGS:

Bland aerosol therapy can be administered in settings that include hospital, clinic, extended care facility, and home.

BAA 4.0 INDICATIONS:

4.1 The presence of upper airway edema—cool bland aerosol[1,2]
  4.1.1 Laryngotracheobronchitis (LTB)[1,2]
  4.1.2 Subglottic edema[1,2]
  4.1.3 Postextubation edema[1,2]
  4.1.4 Postoperative management of the upper airway
4.2 The presence of a bypassed upper airway[3]
4.3 The need for sputum specimens[3,4]

BAA 5.0 CONTRAINDICATIONS:

5.1 Bronchoconstriction[1,3,5,6]
5.2 History of airway hyperresponsiveness[1,2,5,6]

BAA 6.0 HAZARDS/COMPLICATIONS:

6.1 Wheezing or bronchospasm[1,3,5,6]
6.2 Bronchoconstriction when artificial airway is employed[7-11]
6.3 Infection[12]
6.4 Overhydration[12]
6.5 Patient discomfort
6.6 Caregiver exposure to droplet nuclei of *Mycobacterium tuberculosis* or other airborne contagion produced as a consequence of coughing, particularly during sputum induction

BAA 7.0 LIMITATIONS OF METHOD:

7.1 The efficacy of intermittent or continuous use of bland aerosol as a mucoevacuant has not been established.[1-3] Bland aerosol is not a substitute for systemic hydration.
7.2 The physical properties of mucus are only minimally affected by the addition of water aerosol.[13]
7.3 Bland aerosol for humidification when the upper airway has been bypassed is not as efficient or effective as are heated water humidifiers or adequately designed heat moisture exchangers (HME) because of the
  7.3.1 difficulties in maintaining temperature at patient airway,
  7.3.2 possible irritation to the airway,[7-11]
  7.3.3 infection risk.[12]

BAA 8.0 ASSESSMENT OF NEED:

8.1 The presence of one or more of the following may be an indication for administration of a water or isotonic or hypotonic saline aerosol:
  8.1.1 Stridor
  8.1.2 Brassy, croup-like cough
  8.1.3 Hoarseness following extubation
  8.1.4 Diagnosis of LTB or croup
  8.1.5 Clinical history suggesting upper airway irritation and increased work of breathing (eg, smoke inhalation)
  8.1.6 Patient discomfort associated with airway instrumentation or insult

8.2 The presence of the need for sputum induction (eg, for diagnosis of *Pneumocystis carinii* pneumonia[14-16] tuberculosis) is an indication for administration of hypertonic saline aerosol.

BAA 9.0 ASSESSMENT OF OUTCOME:

9.1 With administration of water or hypotonic or isotonic saline, the desired outcome is the presence of one or more of the following:
  9.1.1 Decreased work of breathing,
  9.1.2 Improved vital signs,
  9.1.3 Decreased stridor,
  9.1.4 Decreased dyspnea,
  9.1.5 Improved arterial blood gas values,
  9.1.6 Improved oxygen saturation as indicated by pulse oximetry (S_{pO_2}).

9.2 With administration of hypertonic saline, the desired outcome is a sputum sample adequate for analysis.

BAA 10.0 RESOURCES:

10.1 Equipment—Depending upon the specific application, components may include
  10.1.1 aerosol generator
    10.1.1.1 large volume nebulizer
    10.1.1.2 ultrasonic nebulizer
    10.1.1.3 small volume nebulizer
  10.1.2 heater or cooling device
  10.1.3 patient application device
    10.1.3.1 mist tent
    10.1.3.2 hood
    10.1.3.3 mouthpiece
    10.1.3.4 mask
    10.1.3.5 T-piece
    10.1.3.6 face tent
    10.1.3.7 tracheostomy collar
  10.1.4 corrugated aerosol tubing and water trap
  10.1.5 tissues and emesis basin or container for collecting or disposing of expectorated sputum
  10.1.6 gloves, goggles, gown, and mask
  10.1.7 suction device and catheters
  10.1.8 oxygen analyzer
  10.1.9 device for filtering exhaled gas during sputum induction, with scavenger or filter system.

10.2 Resources—Personnel:
  10.2.1 Level I caregiver may be the provider of service after Level II personnel have established need for a specific device by patient assessment and the first administration has been completed. Level I personnel must demonstrate
    10.2.1.1 proper preparation, measurement, and mixing of solution;
    10.2.1.2 proper technique for administration of solution to be aerosolized;
    10.2.1.3 proper use of equipment;
    10.2.1.4 effective cleaning of equipment;
    10.2.1.5 appropriate disposal of wastes;
    10.2.1.6 ability to encourage effective breathing patterns and coughing techniques;
    10.2.1.7 ability to modify techniques in response to adverse reactions as instructed and to appropriately communicate with physician, detailing the severity of symptoms;
    10.2.1.8 compliance with Universal Precautions and proper infection control procedures.
  10.2.2 Level II—Level II personnel supervise Level I personnel, are responsible for initial assessments and care of the unstable patient, and must demonstrate knowledge and skill related to
    10.2.2.1 indications and limitations for aerosol devices and associated equipment;

10.2.2.2 proper use, maintenance, and cleaning of equipment including filter and scavenging systems;
10.2.2.3 risks inherent to the aerosolized solution and specific devices;
10.2.2.4 procedures for safely disposing of hazardous wastes;
10.2.2.5 breathing patterns and coughing techniques;
10.2.2.6 modification of technique in response to adverse reactions;
10.2.2.7 modification of flowrates and temperature as prescribed, in response to severity of symptoms;
10.2.2.8 assessment of patient condition and response to therapy;
10.2.2.9 auscultation, inspection, and monitoring of vital signs;
10.2.2.10 determination of peak expiratory flowrate, spirometry, and ventilatory mechanics;
10.2.2.11 recognition and response to adverse reactions and complications of procedure;
10.2.2.12 understanding and compliance with Universal Precautions;
10.2.2.13 proper disposition of medical waste.

BAA 11.0 MONITORING:

The extent of patient monitoring should be determined on the basis of the stability and severity of the patient's condition:

11.1 Patient subjective response—pain, discomfort, dyspnea, restlessness;
11.2 Heart rate and rhythm, blood pressure;
11.3 Respiratory rate, pattern, mechanics, accessory muscle use;
11.4 Sputum production quantity, color, consistency, odor;
11.5 Skin color;
11.6 Breath sounds;
11.7 Pulse oximetry (if hypoxemia is suspected).

BAA 12.0 FREQUENCY:

12.1 Critical care or emergency room settings that require continuous administration of bland aerosol necessitate close monitoring.
12.1.1 Short duration: 4-8 hours following extubation
12.1.2 Subglottic edema: until edema has subsided
12.1.3 Long duration: artificial airways
12.1.4 Re-evaluation every 8 hours or with change in clinical condition

12.2 Acute care patients should be evaluated for response to therapy of continuous administration of bland cool aerosol for LTB and re-evaluated at least every 48-72 hours or with change in clinical response.

12.3 Domiciliary patients should be re-evaluated periodically for response to therapy or with change in status.

12.4 Sputum induction should be performed as often as necessary to yield appropriate specimen for desired examination (eg, each morning for 3 days for acid-fast bacillus).

BAA 13.0 INFECTION CONTROL:

13.1 Universal Precautions for body fluid isolation are to be implemented.[17]

13.2 Centers for Disease Control and Prevention recommendations for control of exposure to tuberculosis and droplet nuclei are to be implemented when patient is known or suspected to be immunosuppressed, is known to have tuberculosis, or has other risk factors for the disease.[18]
13.2.1 To reduce aerosol contamination of room air
13.2.1.1 Enclose and contain aerosol administration
13.2.1.2 Filter aerosols that bypass or are exhaled by patient
13.2.1.3 When aerosol release to the atmosphere cannot be routed through a filter,
13.2.1.3.1 Use filtered scavenger systems to remove aerosols that cannot be contained.
13.2.1.3.2 Provide local exhaust ventilation to remove aerosols that are released into room air.
13.2.1.3.3 Provide frequent air exchange to dilute concentration of aerosol in room.

13.2.1.3.4 Allow exchange of gas in the room to eliminate 99% of aerosol before next patient enters or receives treatment in that area.

13.2.1.3.5 Provide booths or stalls for sputum induction in areas in which multiple patients are treated. Booths or stalls should be designed to provide adequate airflow to draw aerosol and droplet nuclei from the patient and into an appropriate filtration system with exhaust directed to an appropriate outside vent. Booths should be adequately cleaned between patients.

13.2.2 It remains unclear whether high efficiency particulate air (HEPA) filters completely remove infectious particles from the air.

13.2.3 Filters, nebulizers, and other contaminated disposable components of the aerosol delivery system should be treated as hazardous waste.

13.2.4 Personal protection devices should be used to reduce exposure when engineering alternatives are not adequate or in place.[18]

13.2.4.1 Use properly fitted respirator with adequate filtration when flow exhaust cannot control removal of aerosols.

13.2.4.2 Goggles, gloves, masks, and gowns should be used to serve as splatter shields and to reduce exposure to body substances.

13.2.5 Personnel should safely dispose of hazardous wastes.

13.2.6 Personnel who are at high risk for adverse effects from exposure should be offered an opportunity for alternative assignments.

13.3 Nebulizers should not be reused between patients without disinfection.

13.4 Nebulizers should be changed or sterilized

13.4.1 at conclusion of a procedure that is not to be repeated,

13.4.2 every 24 hours with repeated or continuous administration or more often when visibly soiled.

13.5 Nebulizers should not be rinsed with tap water between treatments.[19,20]

13.6 Solutions should be handled aseptically.

13.7 Solutions from multidose sources must be handled aseptically and discarded after 24 hours.

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Left Shoulder, Neck, and Chest Pain with Dyspnea and Nonproductive Cough

C Worth Brooks Jr BS RRT and Shelley C Mishoe MEd RRT

A 65-year-old Black woman was evaluated in the emergency room for left-side neck, shoulder, and chest pain. She reported that the pain intensified with neck and shoulder extension. The patient had been in her usual state of health until 2 weeks before presenting to the emergency room when she developed exertional dyspnea and a nonproductive cough. She denied the presence of fever or chills. Past medical history included anxiety, primary hypertension, cervical myelopathy, and generalized osteoarthritis; she was a nonsmoker. Examination in the emergency room revealed that the patient's breath sounds were clear to auscultation on the right side but were decreased on the left. Arterial blood gas analysis indicated moderate hypoxemia. An anteroposterior (AP) chest radiograph was taken and is shown in Figure 1.

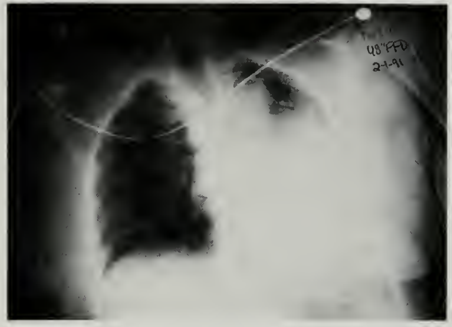

Fig. 1. Anteroposterior radiograph of the chest of a 65-year-old woman with pain, dyspnea, and cough.

Mr Brooks is Instructor and Departmental Director of Admissions and Ms Mishoe is Associate Professor & Chair—Department of Respiratory Therapy, School of Allied Health Sciences, Medical College of Georgia, Augusta, Georgia.

How would you answer these questions?

What abnormalities can be seen in Figure 1?

What are the possible causes of these abnormalities?

What further tests are warranted by the findings observed in Figure 1?

Answers and Discussion on Next Page

Answers

Abnormalities in Figure 1: The most obvious abnormality on the AP chest radiograph in Figure 1 is complete opacification of the left middle and lower hemithorax. The decreased breath sounds noted on the physical exam are consistent with this finding.

Possible Causes: Based on the available information, the differential diagnosis list should include pleural effusion, large-airway mucus plugging, foreign- body aspiration, or bronchogenic tumor. Densities are observable within the soft tissue of the left mid- to lower-lung fields, and atelectasis and infiltration of the left upper lobe and lingula are also suggested. There is a moderate shift of the heart and mediastinum to the left and an elevation of the left hemidiaphragm. Although the patient is slightly rotated, the trachea is clearly drawn to the affected side, which strongly suggests atelectasis.[1] Mediastinal tumors have been known to cause similar shifts and narrowing of the central airways.

Further Testing: The patient was admitted to the hospital for further testing because a pulmonary tumor was suspected. If pleural effusion was present, it was obscured by the silhouette sign from the tumor. Minimal effusion may have been present but it was likely too small to require treatment. Pulmonary Medicine was consulted, and diagnostic procedures were ordered, including a computerized tomographic (CT) scan and fiberoptic bronchoscopy with biopsies. A CT scan of the lung, part of which is shown in Figure 2, revealed that the lingular segment of the left-upper lobe and the left-lower lobe are atelectatic. The scan further demonstrated that the patient's left main-stem bronchus was compressed and almost completely occluded. A 5.5-cm diameter, fairly homogenous, soft-tissue structure is present at and below the left hilum. This structure could be mistaken for atelectatic lung but probably represents pulmonary neoplasm or left hilar lymphadenopathy. Further tests were indicated. Bronchoscopy with biopsy was then performed to obtain a specimen from the left main-stem bronchus. Bronchoscopic examination and CT scan can yield important clinical and tumor-staging information.[2] Cytologic examination of the specimen indicated small cell, undifferentiated carcinoma.

Treatment: The treatment plan for the small cell carcinoma included high-dose localized irradiation to decrease the size of the tumor and relieve the pressure on the left main-stem bronchus allowing the left lung to re-expand. A dramatic improvement in aeration of the left lung followed radiation ther-

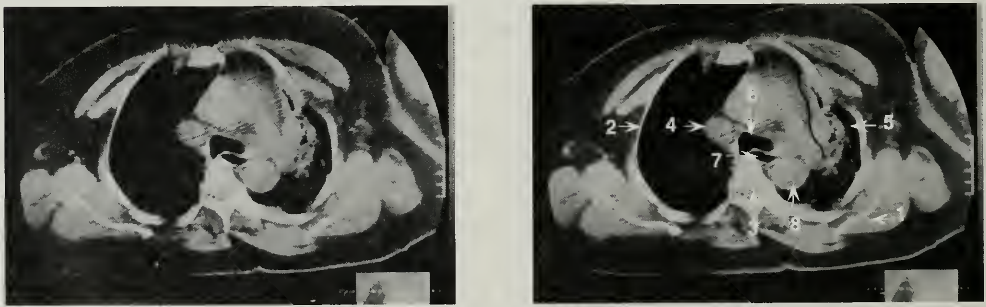

Fig. 2 Computerized tomography at axial scan 8 is a cross-sectional slice of the thorax and, by convention, the view is caudal to cephalad. Picture this patient lying on her back on the CT scan table and you are standing at her feet. In this orientation, the patient's left side is on your right and her right side is on your left. As shown in Figure 2, the vertebral body is down, against the table, and the sternum is up. The left panel is the untouched view and the right panel is annotated to show (1) the scapula, (2) rib, (3) vertebral body, (4) superior vena cava, (5) tumor—the medial border is defined by the solid black line, (6) trachea, (7) esophagus, and (8) descending aorta.

apy (Fig. 3). A multidisciplinary consultation with physicians from Pulmonary Medicine, Medical Oncology, and Radiation Oncology was held to further develop the treatment plan. The patient received a full course of radiation therapy; chemotherapy was suggested as another indicated treatment but was to be added only in the event of a relapse.[3]

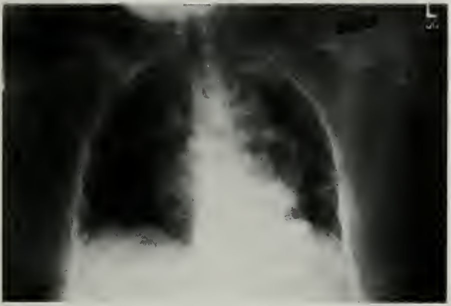

Fig. 3. This anteroposterior chest radiograph shows dramatic resolution of the compression atelectasis noted in Figure 1.

Discussion

Lung cancer remains the leading cause of cancer-related death in the United States,[4] with a mortality rate as high as 80%.[2] Lung cancers are classified as squamous cell, adenocarcinoma, undifferentiated large cell, undifferentiated small cell, bronchiolar-alveolar cell, giant cell, and mixed-cell carcinoma.[5] Factors associated with the incidence of lung cancer include tobacco smoking, male gender, genetic predisposition or family history, industrial factors, and air pollution; an association with tuberculosis has also been observed.[6] Small cell lung carcinoma is an aggressive neoplasm and accounts for about 20% of all lung cancers.[7] Some of the unique features of small cell carcinoma include origination in the proximal airways, production of polypeptide hormones from the tumor site, visualization of hilar and mediastinal node involvement, and early metastatic disease in areas of the brain, liver, bone, bone marrow, and adrenal glands.[7] Metastatic lesions in the adrenal glands have been found in 36% of cases at autopsy; mediastinal nodes are the most common site of metastasis.[8] Several tools are used in the diagnosis of lung cancer. Chest radiographs and sputum cytology are currently the only simple means available for detection of early asymptomatic lung cancer.[4] The initial diagnosis requires AP and lateral chest films. Small cell carcinoma presents as a bulky central lesion with mediastinal fullness[2] as can be seen in the radiograph shown in Figure 1. Sputum cytology is another way to detect early asymptomatic lung cancer and should be attempted when the chest radiograph findings are equivocal. The ability of cell culture to diagnose malignancy depends on the amount of sputum produced and quality of induction. In many cases it is possible to determine the tumor cell-type as well.[9] Early detection provides the best opportunity for long-term survival.[4]

When there is evidence of lobar or segmental collapse on chest radiograph, a CT scan of the chest is indicated.[10] The size of the tumor and the extent of metastasis to the liver and adrenal glands can be accurately determined by evaluating the chest and upper abdomen with CT scan.[2]

Flexible fiberoptic bronchoscopy can locate the site of lung carcinoma at its earliest stage by direct visualization of the tracheobronchial tree.[4] Patients who have undiagnosed peripheral lung tumors on chest film can have a percutaneous biopsy performed under fluoroscopic control.[9] Tumor markers like neuron-specific enolase may also be helpful in diagnosing small cell lung carcinoma.[11]

The treatment for lung cancer falls into three categories—surgery, radiation therapy, and chemotherapy. Advances in chemotherapy and radiation therapy have improved the survival of patients with small cell carcinoma, but this type of lung cancer is always eventually fatal, with survival generally measured in months.[2-4] Because small cell carcinoma spreads early, surgery is usually ruled out, unless the tumor is a solitary peripheral nodule without metastasis to the mediastinum or other sites.[7] Compared to other types of lung cancer, small cell carcinoma is sensitive to radiation and chemotherapy,[3] but even after apparently successful therapy, patients generally relapse and cures are rare.[12-16] Certain chemotherapeutic agents such as etoposide combined with cisplatin can be combined and administered. These drugs work synergistically against small cell lung cancer and generally achieve a positive response in 40-50% of cases; patients tend to survive longer than when either agent is used alone. However, the response to chemotherapy when it follows a course of radiation therapy, is generally decreased and considered poor.[3] Surgical resection of a malignant pulmonary lesion is not recommended once metastasis has occurred.[2]

The patient presented in this paper received radiation therapy. The response of lung cancer to radiotherapy depends on radiation dose, cell type, and tumor size, but, as a general rule, long periods of therapy are necessary to maintain a response.[17] The major role of thoracic radiation therapy in treating small cell carcinoma is local tumor control. Radiation therapy can also be effective in reducing the incidence of brain metastasis.[18] Complications of radiation therapy include esophagitis, pneumonitis, radiation-induced cardiac disease, radiation myelopathy, and brachial plexopathy.[9] For this patient, radiation therapy was successful in re-establishing the patency of the left main-stem bronchus, which led to re-expansion of the patient's left lung. She was discharged from the hospital after a 6-week stay but succumbed to her disease 3 months later.

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INSTRUCTIONS FOR AUTHORS

In addition to case reports strictly involving pulmonary-medicine radiography, case reports involving adult, pediatric, and neonatal critical-care radiography can also be submitted to 'Test Your Radiologic Skill.' However, all case reports should relate somehow to respiratory care. Illustrative radiographs may be of routine chest exams or of other less-common exams such as digital subtraction or computerized axial tomography.

Letter on topics of current interest or commenting on material in RESPIRATORY CARE, will be considered for publication. The Editors may accept or decline a letter or edit without changing the author's views. The content of letters as published may simply reflect the author's opinion or interpretation of information—not standard practice or the Journal's recommendation. Authors of criticized material will have the opportunity to reply in print. No anonymous letters can be published. Type letter double-spaced, mark it "For Publication," and mail it to RESPIRATORY CARE Journal, 11030 Ables Lane, Dallas TX 75229-4593.

Letters

More Objections to Branson-Chatburn Humidification Editorial

I disagree vehemently with several of the points raised in the editorial by Branson and Chatburn in the May issue of RESPIRATORY CARE.[1] I *do* agree with the contention that removal of the heated water-bath humidifier (HWBH) from the inspiratory circuit is useful in that it eliminates that component's well-documented role in providing a favorable vector for cross-infection.[2-5] But, certainly one cannot seriously claim that substitution of a heat/moisture exchanger (HME) for the HWBH results in a tubing circuit devoid of organisms! Indeed, numerous studies[6-10] demonstrate that patients (and their indwelling endotracheal tubes) serve as the primary source of organisms, whereas condensate serves merely as a reservoir for the replication and spread of those organisms. Hedley and Allt-Graham demonstrated that simulated saliva and contaminants breached commercially available devices labeled either "heat/moisture exchanging filter" or "hygroscopic condenser humidifier."[11] Once liquid finds its way into the circuit, it poses a serious risk to the caregiver.[12] It can just as easily pass back through the device to reinfect the patient. Craven and coworkers[3] and Bryant et al[9] have shown that the endotracheal tube is contaminated in the process of intubation, and that the expiratory and inspiratory tubing circuits grow out potential pathogens 2 and 4 hours later, respectively. Even patients with no history of pulmonary disease produce a considerable quantity of pulmonary secretions over a 24-hour period. The presence of an indwelling inflatable cuff creates a situation wherein those secretions can only be cleared through the lumen of the tube instead of being coughed out or silently swallowed. Furthermore, although an HME obviates the need to insert an HWBH, certain HMEs may themselves produce bacterial aerosols.[13] This being the case, simple common sense, coupled with concern for those who frequent the bedside (caregivers, nonclinical hospital staff, and visitors), would dictate that one mount a competent bacterial/viral filter at the patient Y-piece to protect the patient and prevent mobilization of potentially infectious aerosols into the bedside environment. In reports published by my colleagues[14] and me,[15] only one commercially available brand of breathing circuit filter—the Pall—was capable of filtering ribavirin aerosol. The inability of other filters to trap ribavirin aerosol particles having a mass median diameter between 1.2 and 1.41 μ was extremely worrisome and led us to wonder what types and numbers of organisms were likewise able to breach other units billed as "bacterial/viral filters." Reports published elsewhere have amply justified our high regard for the Pall filter and reinforced our low regard for several other so-called "filters."[11,16-18]

A list of contraindications for HMEs has been published[19] and constitutes the original such listing for these devices. These contraindications are (1) the presence of copious secretions, (2) excessive leakage past the indwelling intratracheal cuff, and (3) substantial leakage through a bronchopleural or pleurocutaneous fistula. It is puzzling that Branson's algorithm recommends that patients be placed on an HWBH if and when visible amounts of secretions are observed within the HCH more than four times per 24 hours. On what basis was this number chosen? Caregivers would be well advised to remove the HME from the circuit when one initially notes copious amounts of secretions on the patient side of the device, and not after the fourth such episode. This is predicated not on the relative cost of the HME versus the cost of operating an HWBH but rather on the risk of auto-PEEP that occurs when secretions have been mobilized into the HME.[19]

On another topic related to contraindications for HMEs/HMEFs, Branson and Chatburn cite studies that describe tracheal tube occlusions with HMEs. Although admitting that "One problem with all of these studies is that no exclusion criteria for the use of the HME were used,"[1] they chose not to include the published information that has clarified or criticized these same studies. Specifically, a letter to the editor by the authors of one of the studies listed, Missett et al,[20] states, "Since we performed our study, we have used the Pall HME routinely in 560 consecutive patients for a total of 5,880 days of MV, using the same methods as those described in our article. No fatal tube occlusion occurred during this period, and difficulty in suctioning resulted in replacement of the HME by an HH in 14 patients." With respect to the paper by Cohen et al,[21] a letter to the editor published[22] subsequently states, "Cohen and coworkers were interested in assessing the performance of a heat/moisture exchanging filter (HMEF) in unselected consecutive mechanically ventilated patients admitted to their ICU. It is not surprising that 9% (15/170) of these patients subsequently required conversion to a heated humidifier. . . . The article by Cohen et al is a useful report demonstrating that no device should be applied to patients in the presence of potential contraindications."

Branson and Chatburn[1] claim that the incidence of nosocomial pneumonia in the studies by Roustan et al,[23] Martin et al,[24] and Missett et al[25] was similar, regardless of the humidification method used. But, both Roustan and co-workers and Martin and colleagues reported reductions in nosocomial pneumonia rates of 37-38% with the Pall HMEF. Although these figures approached, but did not reach, statistical significance, most clinicians would find a reduction of this magnitude to be worthwhile. Indeed, Martin et al[24] state that "The filter [Pall HMEF] is efficient in preventing circuit contamination by patient germs and seems to lower the incidence of nosocomial pneumonias." Missett's group[25] states that "No attempt was made to assess the incidence of pneumonia," so I am at a loss to understand how Branson and Chatburn can draw any inferences either way with regard to that study.

In closing, then, I oppose any suggestion that caregivers relax their vigilance with respect to eliminating their vulnerability, and that of their patients, to pathogen-laden aerosols.[19] I find the content and tone of the Branson-Chatburn editorial to be unfortunate and singularly ill-timed and many of their conclusions to be unsupportable by the references that they cite.

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and moisture exchanger vs heated humidifier during long-term mechanical ventilation: a prospective randomized study. Chest 1991;100: 160-163.

Mr Branson responds:

Because most of Mr Demers's complaints deal with my portion of the editorial,[1] I will respond. I do, in fact, suggest that the absence of condensate in the circuit creates a hostile and unacceptable environment for bacterial growth. His letter agrees with my previously stated point—that patients infect the circuit, not vice versa. His point that condensate serves as a reservoir is also in agreement with what I suggested. The paper by Hedley and Allt-Graham supports the superior filtering capabilities of the Pall HME, something we neither mentioned nor denied.[2] My point of contention with the Pall HME is not its filtration characteristics but its inadequate humidification capabilities. Mr Demers makes the statement "Once liquid finds its way into the circuit, it poses a risk to the caregiver," but when one uses an efficient artificial nose, there is no condensate in the circuit. Without rewriting the editorial, I will summarize the data on this point. In our study, we cultured circuits at the patient Y-piece and failed to find a single organism except for two cases of contamination by *Staphylococcus epidermidis*.[3] The study by Ibrahim and Perceval[4] found that circuits seeded with *Streptococcus viridans* (10^7 organisms/mL) failed to contaminate dry gases.[4] Yet even their experimental situation allowed the placement of condensate in the circuit, something that we have not observed in hundreds of patients using hygroscopic condenser humidifiers (HCHs). Other authors agree with these findings.[5,6]

The references that Mr Demers cites support my contention that the patient is the primary source of organisms in the circuit. The article by Craven et al[7] does demonstrate that condensate is a potential source of "re-infection" in mechanically ventilated patients; however, this is an irrelevant point when an HCH is used.

I did not suggest that the Pall HME was not an efficient filter. My point was that filtering gases does not appear to decrease the incidence of nosocomial pneumonia. The concept that caregivers should be protected from the patient's organisms was not discussed in the original editorial.

In regard to support for Mr Demers's statement that condensate "poses a serious risk to the caregiver"—Malasky et al[8] used a questionnaire to determine the rate of tuberculin skin test conversion of pulmonary and infectious disease fellows from public hospitals. They found that 11% (7/62) of pulmonary fellows and 2.4% (1/42) of infectious disease fellows converted over a 3-year period. The paper reviews the literature on skin test conversion rates and suggests that an increased risk of exposure to aerosolized droplets is present during intubation and bronchoscopy. I read the paper three times—the words "circuit" or "serious risk" are not used. In fact, the paper contains absolutely no discussion of ventilator circuit condensate.

The sentence in our algorithm "evaluated secretion quality and quantity" refers to the practitioners' use of the scale described by Suzukawa et al[9] to assess the quality of pulmonary secretions. If two consecutive suctioning attempts result in the retrieval of sputum judged to be "thick," patients are placed on a heated humidifier. In our experience, it frequently happens that patients with thick secretions never contaminate the HCH. Patients also have thin secretions and do occasionally cough into the HCH. When this soiling occurs frequently (> 4 times), it is cost-efficient to use a heated humidifier. Our algorithm has a built-in system for dealing with "copious" secretions. (The word copious was not used in the editorial or the algorithm.) The prospective study of over 100 patients supports my contention.[3]

Mr Demers suggests that auto-PEEP may occur if the HCH/HME is contaminated with secretions. Although this may be one consequence of increased resistance (which, by the way, was first suggested by my colleagues and me[10,11]), this finding has never been demonstrated.

Mr Demers complains because I did not acknowledge the letters to the editor written by him and others concerning the unfavorable results seen with use of the Pall filter.[12,13] However, he fails to mention that the letter by Misset et al[12] accompanies another letter by Sottiaux.[14] Sottiaux, like Martin et al[15] "suspended evaluation of the PUBF during prolonged ventilation following several dramatic instances of tracheal tube occlusion.[14] Sottiaux further commented, "In spite of the very high efficiency of the PUBF as a bacterial filter, we decided that its use as a passive humidifier should definitely be avoided."[14] Sottiaux et al published results of a study comparing the Pall to two hygroscopic devices (Gibeck and Hygrobac DAR) and commented "Referring to minimal criteria published by several authors,[15-17] the Pall filter appears to be unsatisfactory, even with relatively low V_T. Several studies have corroborated the poor performance of the Pall filter.[18-21] A study was interrupted after the death from total endotracheal tube obstruction of a patient using a Pall BB-50."[19] Thus, we have four clinical studies and a laboratory evaluation[22] demonstrating the ineffectiveness of the Pall HME in the ICU.

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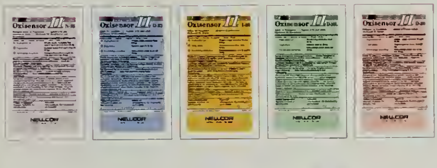

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The incidence of nosocomial pneumonia in the studies by Roustan[20] and Martin[18] do not show a reduction in nosocomial pneumonia rates of 37-38% as Mr Demers suggests. Roustan et al state “Incidence of nosocomial pneumonia did not significantly differ between Groups I and II (9/61 vs 5/55, $\chi^2 = 0.876$, $p > 0.25$).”[20] That represents an incidence of 14% and 9%, respectively. Martin et al state “Seven percent of patients in the PUBCF and 19% in the HHWS developed a nosocomial bronchopneumonia during the study. This difference did not reach the level of significance.”[18]

Finally, Mr Demers suggests that I think caregivers “should relax their vigilance with respect to eliminating their vulnerability, and that of their patients, to pathogen-laden aerosols.” I suggested no such thing. I simply stated the facts based on the scientific literature. My conclusions are well supported and I stand behind the contentions in my original piece.

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EFFECTS OF ITEM DELETION ON THE KUDER-RICHARDSON FORMULA 21 RELIABILITY INDEX IN A MULTIPLE CHOICE EXAM David W. Chang, EdD, RRT, Columbus College, Columbus, Georgia. Introduction: Test reliability is an essential element in the accreditation of RT programs. It is affected by many factors, among them the number of items in an exam. Inappropriate contents, insufficient clues are two reasons which require question items to be deleted from an exam. I sought to determine whether item deletions in a multiple choice exam affect its reliability index (RI). Method: A 94-item multiple choice exam was given to 16 RT sophomore students. The exam was scored by Scantron Form 2200. Item analysis was done to note individual responses to each item of the exam. RI of the exam was calculated by Kuder-Richardson Formula 21 (K-R21): $\text{K-R21} = 1-[x(n-x)/ns^2]$ where x = mean score; n = number of items; and s^2 = test variance. Item deletions were done as follows: (A) Four items that were answered correctly (AC) by all students, (B) Eight items that were AC by all students, (C) Items that were answered incorrectly (AI) by 12 or more students, (D) Items that were AI by 11 or more students, (E) Items that were AI by 10 or more students, (F) Items that were AI by 9 or more students, (G) Items that were AI by 8 or more students. RI was calculated for each of the seven conditions. *t*-test was used to analyze statistical significance. Results: Before item deletion, the RI was 0.695. After item deletions, the RI(items deleted) were 0.700(4), 0.705(8), 0.694(1), 0.688(3), 0.666 (7), 0.672(10), and 0.648(16), respectively. The calculated *t* was 1.688. Conclusions: There was no significant change in the RI when exam items were deleted, whether they were AC or AI.

OF-93-008R

COMPARISON OF RELIABILITY INDICES BETWEEN SPEARMAN-BROWN FORMULA AND KUDER-RICHARDSON FORMULA 21 IN A MULTIPLE CHOICE EXAM David W. Chang, EdD, RRT, James H. Hiers, MEd, RRT, Columbus College, Columbus, Georgia. Introduction: Test reliability is an essential element in the accreditation of RT programs. The reliability index (RI) of an exam may be calculated by many formulas, among them two commonly used formulas—Spearman-Brown Formula (SBF) and Kuder-Richardson Formula 21 (KR-21). We sought to determine whether there was any significant difference between these two reliability formulas in a multiple-choice exam. Method: A 94-item multiple choice exam was given to 16 RT students. The exam was scored by Scantron Form 2200. RI of the exam using the SBF was calculated as follows: $\text{RI(SBF)} = 2(r)/1+r$ where r is the correlation coefficient using the split-half (odd and even items) technique. RI of the exam using the KR-21 was calculated as follows: $\text{RI(KR-21)} = 1-[x(n-x)/ns^2]$ where x = mean score; n = number of items; and s^2 = test variance. Fisher's z transformation, $z = [\text{Z RI(SBF)} - \text{Z RI(KR-21)}] / \sqrt{[1/(N-3) + 1/(N-3)]}$, was used to evaluate statistical difference of the RI's derived from the SBF and KR-21 formulas where Z = table value corresponding to the RI; N = number of students. Results: The RI(SBF) was 0.763 and the RI(KR-21) was 0.695. The Fisher's z transformation among these two RI's was 0.37. Conclusions: There was no statistical difference between the RI's using either the SBF or KR-21 in this 94-item exam. Since KR-21 reflects the RI of all possible split-half techniques, it is the preferred formula to use if more precise RI measurement is desired.

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IMPROVEMENT IN RESPIRATORY THERAPY STUDENTS' ATTITUDES TOWARD THE ELDERLY FOLLOWING INSTRUCTION IN GERONTOLOGY. Susan Perkins MA RRT - The University of Alabama at Birmingham, Birmingham, Alabama. Negative attitudes of health professionals concerning the elderly can influence the care of elderly patients. Using a pretest-posttest control group design, this study sought to determine if respiratory therapy students' attitudes toward the elderly improved after their completion of instruction in gerontology. The Attitude Toward Old People Scale (KAOP), developed by Kogan (1962) was used for the assessment of attitudes. Respiratory therapy students (n=40), enrolled in a course on pulmonary rehabilitation and home care, were randomly assigned to experimental and control groups. Subjects in the experimental group were given five hours of instruction in gerontology and a clinical assignment with acutely ill elderly patients. Students in the control group were given class time to develop an individualized care plan for a patient with COPD, and a clinical assignment with other age groups. The KAOP was administered to all students before and after the experiment. Posttest scores on the KAOP for the experimental group were compared with those of the control group utilizing analysis of covariance (ANCOVA) with pretest scores on the KAOP serving as the covariate. The hypothesis predicting an increase in positive attitudes was supported. Significant differences in overall attitude scores between the two groups were found to exist after the effect of the pretest scores was accounted for (F = 22.551, P = .000). Data from this study have implications for the inclusion of instruction in gerontology in respiratory therapy program curricula.

OF-93-052

Measurement of End-Exhalation Occlusion Pressures By Respiratory Therapists has Minimal Inter-observer Variability. Shane Elliott,RRT, Jennifer Anderson,RRT, Lisa Previte,RRT, Tom Taylor,RRT, Lennard Specht,MD. Medical Service Jerry L. Pettis Memorial VAMC, Victor Valley College Department of Allied Health Professions and Loma Linda University School of Medicine 11201 Benton St. Loma Linda, Ca. 92357.

Measurement of pulmonary mechanics in patients requiring mechanical ventilation is highly variable. We sought to assess the inter-observer variability of measurements of auto-PEEP using the end-exhalation occlusion pressure. For 6 months, two times per week 4 registered respiratory therapists measured the end-exhalation occlusion pressure on every ventilator dependent patient at our facility. Each measurement was performed independently three times by every therapist. The individual measurements were averaged and reported by each therapist. A small subgroup also had auto-PEEP measurements taken by second year respiratory therapy students in the same manner. In the 53 patients that we studied we had an average auto-PEEP of 4.41 (± 4.5) cmH_2O. 16 of 53 patients had auto-PEEP levels of $\geq 5cmH_2O$. The average variability for the end-exhalation occlusion pressure measurement performed by our respiratory therapy staff was 1.76 cmH_2O. The only significant factor that we identified that would predict high degree of inter-observer variability was a high level of auto-PEEP ($R^2 = 0.302$). In the sub group of patients (22) in whom measurements were made by both therapists and students, the students overestimated the auto-PEEP level by 1.41 cm H_2O ($P < 0.02$) compared to the therapists measurements We conclude that a significant fraction of our ventilator dependent patients have an auto-PEEP level of 5 cmH_2O or greater. The variability in the end exhalation occlusion technique when measured by practicing therapists is small. There is a significant difference in the measurement of end-exhalation occlusion pressures measured by respiratory therapy students compared to our respiratory therapy staff.

OF-93-057

ASSESSING RESPIRATORY CARE PRACTITIONERS' ASSESSMENT SKILLS BY PERFORMANCE ON CASE STUDIES: STUDENTS vs. THERAPISTS vs. INSTRUCTORS.

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Although therapist-driven protocols are increasingly popular, successful implementation requires confidence in assessment skills and implementing treatment algorithms. To assess the level of respiratory care practitioners' (RCP) preparedness for evaluate-and-treat programs, we undertook the following survey in which 6 case studies of non-ICU, non-mechanically ventilated patients were mailed to 1,200 RCPs (960 students, 100 staff RCPs, 140 RCP instructors) in 62 schools and 10 hospitals. Using treatment algorithms from the Cleveland Clinic Foundation Respiratory Therapy Consult Service, respondents were asked to generate a respiratory care plan for each case study. "Correct" answers were identified beforehand by expert consensus. Individual respondents' answers were graded against the correct answers. The overall response rate was 46.1% (students 50.8%, staff 32%, instructors 24.2%). The overall rate of correct responses was 49.0% ± 18.6% (S.D.). Comparison of response rates by training level showed that instructors performed better than staff RCPs who performed better than students (64.1% ± 15.5% vs. 54.8% ± 18.2% vs. 47.5% ± 18.3% respectively, $p<0.05$). In contrast, rates of correct responses were no higher among students completing 4 year vs. 2 year vs. 1 year (technician) programs (44.9% ± 20.2% vs. 47.8% ± 18.4% vs. 47.8% ± 16.4%, $p>0.05$). Although 64% of 438 responding students reported being comfortable with protocols, their correct response rate was 46.8% ± 18.1%. We conclude: 1) The overall rate of correct responses to case studies using treatment algorithms was disappointing in this study. 2) Among respondents, instructors demonstrated the highest frequency of correct responses, exceeding staff therapists and students, and 3) No effect of length of training program was apparent in this study, though overall student performance was low.

OF-93-071

DEVELOPMENT OF A SAFETY MODULE TO SATISFY OSHA AND JCAHO REQUIREMENTS.

Gary R. Lowe, RRT, BS. Arkansas Children's Hospital, Little Rock, Arkansas.

INTRODUCTION: We developed a self administered departmental safety module (SM) to instruct Respiratory Care (RC) employees in their responsibilities during emergency situations. The SM has five phases: a pre-test (PRE) module objectives, presentation of information via outline form, a post-test (POST) and review of the POST. This training meets the specific requirements outlined by OSHA and JCAHO. METHOD: To evaluate the effectiveness of the SM, we compared test scores between three groups of employees: those with no previous exposure to safety in the hospital setting (G1), those with exposure at other institutions (G2) and those with exposure at this institution (G3). RESULTS: Using independent t-test analysis we compared the differences in PRE and POST scores of the three groups; G1 to G2 ($p = .008$), G1 to G3 ($p = .0001$) and G2 to G3 ($p = .045$). Comparison of POST scores in the three groups showed G1 to G2 ($p = .008$), G2 to G3 ($p = .883$) and G1 to G3 ($p = .008$). CONCLUSION: Previous exposure to hospital safety management caused significantly higher PRE scores but did not significantly improve POST scores. No exposure led to the greatest improvement; although the POST scores for G1 were significantly lower, they were sufficient to pass (80%). This self administered SM is an effective and efficient method of educating RC personnel in safety issues. Further evaluation of this process will include assessment of employee knowledge retention. OF-93-085

MDI KNOWLEDGE AMONG HEALTH PROFESSIONAL GROUPS.

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MDI technique was observed for correctness among 86 medical personnel. (RRT/32, CRTT/11, RN/34, pediatric residents/10). Steps were scored on proper use of MDI's. The steps are: remove cap, shake canister for 5 seconds, holding canister upright and exhaling fully, location of mouth piece, (closed mouth, open, at 2 or 4 cm), squeeze MDI with slow inspiration, 10 second breath hold, and when to deliver the second dose. Other questions were: how often they instruct use of MDI and how they learned to use MDI's. The most correct steps observed were by the RRT 86.5%, CRTT 80.3%, pediatric residents 80.0% and RN 64.7%. Breath hold was not only variable (range 0-1 minute) but often incorrect with only 61.9% of the group performing a 10-second hold. Mouth placement was also significantly variable amongst all participant types with 47.6% using the closed mouth technique, 12.8% using the open, 38.4% at 2 cm and 11.6% at 4 cm. (p 0.03, 0.02, 0.001 and NS respectively). Health care provider education was equally as variable with 31% learning on-the-job training, 29% trained in school, and 12% from personal use. Of the participants, 22% frequently instruct, 62% occasionally or 16% never teach their patients use of MDI's. Overall, the RT's had the highest percentage of correct steps.

OF-93-137

LEARNING AND GRADE ORIENTATION AMONG FACULTY AND STUDENTS IN RESPIRATORY CARE PROGRAMS—Dunlevy CL, EdD, RRT, Fessler S, BS, CRTT, Douce FH, MS, RRT, Op't Holt TB, EdD, RRT. The Ohio State University, Columbus, Ohio.

Introduction: A student's academic behavior is often influenced by one of two possible orientations toward the classroom situation, termed learning orientation (LO) and grade orientation (GO). LO describes an attitude held by those students who approach the college experience to acquire knowledge and obtain enlightenment. GO describes an attitude held by students who view obtaining a good course grade, in and of itself, as a reason for being in the classroom. The purpose of our study was to determine the LO and GO of faculty and staff in respiratory therapy programs. **Methods:** 101 respiratory care programs (BS, AS, and vocational) were randomly selected from the JRCRTE accreditation list to participate in the study; response was 61%. 794 students completed the LOGO (learning orientation/grade orientation) questionnaire, and 150 faculty completed the LOGO F (for faculty) questionnaire. The surveys, designed by James Eison, PhD, consisted of 32 (LOGO) or 20 (LOGO F) questions, and are intended to measure students' attitudes and behaviors toward LO and GO. Students & faculty responded to statements on a 5-point Likert scale. LO and GO scores were computed for each respondent, means & standard deviations were calculated for each group, and two-tailed paired t tests were performed, using an alpha level of 0.05. One-way ANOVA was performed on demographic data, to determine whether any item had a significant effect on LO or GO scores. F values were calculated, with $p < 0.05$ considered statistically significant. **Results:** Two-tailed paired t tests showed that RC faculty scored significantly lower than RC students on both LO ($t=41.96$; $p<0.01$) and GO ($t=31.09$; $p<0.01$) total scores. One-way ANOVA revealed that RC students from vocational programs received lower LO scores than students from AS or BS programs ($F=8.01$; $p=0.002$). Means for RC faculty LO and GO scores were significantly lower than total scores reported for faculty in the literature ($p<0.01$). **Conclusions:** The literature describes high LO/high GO students as tough-minded & realistic, extroverted, believers in luck or fate, with low levels of abstract reasoning and high levels of debilitating test anxiety. Low level LO/GO scores describe faculty who are more introverted, with high levels of tension and frustration. Because RC faculty scored lower on both LO & GO scores compared to their students, numerous implications exist to restructuring classroom experiences, so that student learning is enhanced. OF-93-139

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SURVEY OF RESPIRATORY CARE PRACTITIONERS FOR THE PERCEIVED VALUE OF CHEST AUSCULTATION

Robert L. Wilkins MA RRT, Mark Olfert BS CRTT, and Lennard Specht MD, Loma Linda University, Loma Linda, Ca.

Introduction: Chest auscultation (CA) has been taught in medical curriculums for hundreds of years but now represents only one of many assessment tools. As a result, current educators may have a difficult time determining the appropriate amount of emphasis to place on CA. We attempted to determine if the perceived value of CA varies with years of experience and other variables among respiratory care practitioners (RCPs). Alterations in curriculum may be needed if the perceived value of CA is found to vary significantly with increases in years of experience. **Method:** We mailed 1100 surveys to California RCPs. Respondents were asked to indicate age, credentials, college degree, auscultation frequency and type and amount of patient care experience. In addition, respondents were asked to indicate on a Likert scale of 1 to 5 with 5 being highest, their opinion on the value of CA for the initial assessment of a patient and for evaluation of the effects of treatment. Chi square was used to identify significant correlations. **Results:** Four hundred and sixty three completed surveys were returned for a return rate of 42%. Most participants rated CA for initial and treatment assessment very valuable with a mean value of 4.4. The perceived value of CA did not vary with years of experience, or credentials, college degree, and type of patient care experience. Chronological age and frequency of use were found to have a significant relationship with the perceived value of CA. An increase in chronological age is associated with a decrease in the perceived value of CA ($p < .01$). Use of CA is less in those with a lower value rating for auscultation ($p < .005$). **Conclusions:** Many California RCPs rate CA to be very valuable and their rating is independent of years of clinical experience. Older RCPs do not rate CA to be as valuable as compared to younger RCPs and those who rate it to be of less value use it less often. Respiratory care educators are justified in emphasizing CA.

OF-93-169

CHEST PERCUSSION FOR RESONANCE IS NOT ROUTINELY USED BY MOST RESPIRATORY CARE PRACTITIONERS

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Introduction: Chest percussion (CP) to evaluate underlying lung resonance is an assessment procedure often taught in medically related programs. Educators may be unsure of how much emphasis to place on such procedures when its exact role and value are not clear. We attempted to identify the perceived value and frequency of use for CP to evaluate resonance among Southern California respiratory care practitioners (RCPs). **Methods:** We mailed 400 surveys to Southern California RCPs. Respondents were asked to indicate their age, years and type of experience, college degree, and credentials. In addition participants were asked to mark their frequency of use and perceived value of CP to evaluate lung resonance. The perceived value was marked on a Likert scale of 1 to 5 with 5 being most valuable. Chi square was used to identify significant relationships. **Results:** Of the 400 surveys mailed, 155 (39%) were returned. Almost 33% of participants rated CP to evaluate resonance of minimal or no value. About 42% rated it to be of some value and 26% rated it to be very valuable. Approximately 56% of participants indicated that they never use CP to evaluate resonance. About 30% use it one to two times per work week and only 14% use it daily. Variance in the perceived value of CP was independent of years of experience, type of experience, college degree, and chronological age. Registered respiratory therapists (RRTs) were found to rate CP lower and use it less often as compared to certified respiratory therapy technicians (CRTTs)($p < .01$). **Conclusions:** There is a wide variance of opinion among Southern California RCPs on the value of CP to evaluate lung resonance. Most RCPs rarely or never use it. RRTs rate it lower and use it less often as compared to CRTTs. Educators should not emphasize the use of CP for resonance in the day to day management of patients. The results should not be interpreted to indicate that the use of CP to assess resonance is not useful in selected situations.

OF-93-170

INTERRUPTION OF OXYGEN THERAPY DURING INTRA-HOSPITAL TRANSPORT OF NON-ICU PATIENTS.

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Pts receiving O_2 therapy often leave their beds to go to other areas of the hospital. Interruption of O_2 therapy, in acutely hypoxemic pts could result in complications, including life-threatening arrhythmias or even cardiorespiratory arrest. In our hospital O_2 therapy on acute-care wards is supervised by RC and/or nursing. Providing O_2 during intra-hospital transportation (INT) is the responsibility of other services - radiology, physical therapy, operating room, nursing and the transportation department (TD). This study sought to answer the following questions: In our hospital how often do pts on continuous O_2 leave their rooms accompanied by the TD and do not receive O_2 during INT? How is INT of non-ICU O2 pts handled in other hospitals? Methods: We collected data from TD and RC department. O_2 records to determine how many times the TD transported pts ordered for continuous O_2 and how often O_2 was provided during the INT. We also conducted a telephone survey of 20 hospitals in our state with at least 150 beds to determine how O_2 pts were transported. Results: Initial compliance with the standard was poor (see table). We then convened a team consisting of RC, nursing, Radiology and TD personnel, and identified the following problems: miscommunication between transporters and the unit assistants, and independent nursing decisions that pts are "OK" to transport without O_2. We developed a plan to correct these problems including notification of TD of needed pt transports by the RN, so that correct information can be communicated, and the posting of signs as visual reminders to nursing managers to encourage compliance with the O_2 transport standard. Our second audit showed 80% compliance. The team met again and generated a plan that would provide education for RN's on safe INT of O_2 pts. Our third audit resulted in 100%. compliance. Our telephone survey found that of the 20 hospitals, 11 had a separate TD; in 8 RNs were responsible for pt INT and in 3 responsibility was shared by nursing, TD and ward clerk. RC was not involved in any routine acute care O_2 pt INT; in 9 without a TD, non-professional personnel were responsible for INT in 8 and RNs in 1. Of the hospitals surveyed only one had audited to see if O_2 orders were complied with during INT of O_2 pts. Conclusions: Pts receiving continuous O_2 are often transported to other areas of the hospital without O_2. The system in our hospital is not unique. Direct involvement of the RC Department in the education & training of other hospital personnel can make a difference of in quality of pt care. OF-93-177

	O2 Pt Days	Transports	With O2 (%)
1st Audit	125	55	30 (55)
2nd Audit	82	35	28 (80)
3rd Audit	99	35	35 (100)

PROFICIENCY IN APPLYING TREATMENT ALGORITHMS : TRAINING AT CLINICAL SITES USING THERAPIST-DRIVEN PROTOCOLS IS ASSOCIATED WITH BETTER PERFORMANCE.

Susan P. Pilbeam, MS, RRT, Rebecca L. Meredith, RRT, Kevin McCarthy, RCPT, and James K. Stoller, MD,. Greenville Technical College, Greenville, SC & Cleveland Clinic Foundation, Cleveland, OH.

The increased popularity of Therapist Driven Protocol (TDPs) requires that Respiratory Care school curricula include instruction in assessing patients and in applying treatment algorithms. As part of a larger study of Respiratory Care staff and students' proficiency in applying treatment algorithms (10 hospitals and 62 schools), the current study assesses whether affiliation with hospitals using TDP's affects staff and students' abilities to establish correct care plans in 6 case studies about non-ICU, spontaneously breathing patients. In the current study, staff and students in 10 hospitals and 62 schools were invited to participate. Eight (80%) of the hospitals and 45 schools (73%) responded. The 8 responding hospitals were affiliated with five different two-year RC programs. Of the 8 hospitals, TDPs were in use for at least one year in three of the hospitals, for less than one year in another two and not at all in the remaining three. There were a total of 69 Respiratory Care staff member responses from the 8 hospitals. Of these 50 staff represented hospitals with TDPs in place more than one year and 19 were in hospitals with no TDPs in place or where they had been in place for less than one year. The five two-year RC programs who affiliated with hospitals doing TDPs more than one year were compared to 24 other two-year RC programs. Overall, the rate of correct responses for all groups to assigning a respiratory care plan in the 6 case studies was 49.0% ± 18.6% (S.D.) compared to a 100% possible score. Students representing affiliation with hospitals using TDPs for more than one year scored higher (median = 59%) than students from other two-year programs (median = 50%, $P < 0.001$). Similarly, staff representing hospitals using TDP's for more than one year scored higher (median 78.1%) than staff from non-TDP hospitals or those using TDPs for less than one year (median = 21.9%, $P < 0.001$). We conclude: 1) The overall scored responses prescribing respiratory care in six case studies were low for both students and staff. 2) Compared to staff in hospitals not employing TDPs, staff in hospitals using TDPs longer than one year scored higher. 3) Compared to students affiliated with non-TDP hospitals students affiliated with hospitals using TDPs longer than one year scored higher. 4) The results suggest that training at clinical sites where TDPs are used is associated with greater proficiency in applying treatment algorithms.

OF-93-194

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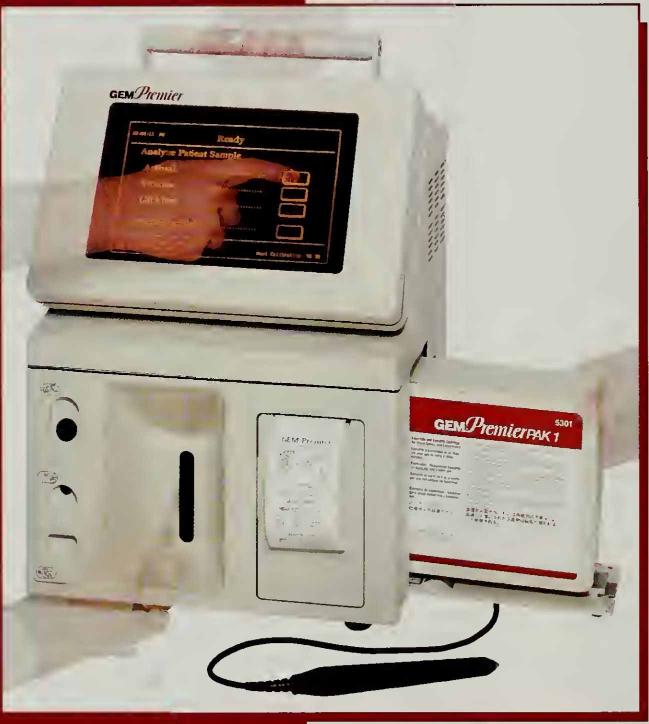

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NON-INVASIVE MASK VENTILATION AS AN ALTERNATIVE TO INTUBATION IN ACUTE RESPIRATORY FAILURE (ARF)-

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In our study, mask ventilation (MV) has proven to be a successful alternative to intubation in some ARF patients. Method: Using a Bird 8400 or a Puritan Bennet 7200 with proper nasal or full face mask, we successfully oxygenated and ventilated 10 ARF patients who would have otherwise needed intubation. Patients were selected after a diagnosis of Respiratory Failure was given. Patients had to be alert and minimal secretions. Of 10 patients studied, 7 were admitted in ARF, 2 were admitted with acute MI, and last suffered respiratory failure due to post-op complications. Seven of 10 patients survived acute episode. MV patients were selected due to ARF with increasing respiratory acidosis or acute refractory hypoxemia. ABG's were corrected with an average of 5.1 hours. Average time spent on ventilator was 2 days. Advantages of MV would include no hemodynamic compromise, due to increased diameter of trachea instead of narrowing airway with an ET tube and increasing pressures in chest, no intubation complications, and no sedation required. Also, patients were able to eat and communicate throughout ventilation period. Weaning was also facilitated with MV due to decrease in airway resistance usually associated with an E.T. tube. Only complication we observed was a mild necrosis across bridge of nose which was caused by tight fit required by mask. Otherwise, no complications were observed. Modes of ventilation were determined by patient need, all modalities were used, including AC, SIMV, and CPAP. Patients who expired wished no intubation or chemical resusitation but allowed MV in hopes of prolonged life. Conclusions: Although 3 patients expired due to medical complications unassociated with MV, we found it to be an effective alternative to intubation in patients with ARF. OF-93-002R

ELECTIVE EXTUBATION FAILURES IN A SURGICAL ICU USING A ROOM AIR-CPAP TRIAL CRITERIA: FREQUENCY AND CAUSE.

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INTRODUCTION: Traditional extubation criteria are based on measurements inferring adequate respiratory muscle pump strength and endurance. These criteria suffer from variable patient effort and inconsistent reproducibility. We examined the cause and rate of extubation failures (i.e., reintubation with 24 hours) following a 20 minute Room Air (RA) continuous positive airway pressure (CPAP = 5cm H_20) trial in a 20 bed Surgical ICU. **METHODS:** During a 9 month period, we prospectively followed 242 consecutive surgical and trauma patients undergoing elective extubation. All patients were weaned using IMV with or without PSV to achieve a respiratory rate (f) ≤ 30 breaths/min. PEEP was titrated to achieve $SaO_2 \geq 90\%$ and $PaO_2 \geq 65$mmHg with $FI0_2 \leq .30$. At minimal support (PEEP = 5cm H_20, IMV = 0-2, PSV < 10cm H_20) a CPAP/RA trial ($FI0_2 = 0.21$) was performed. Extubation occurred if $Pa0_2 \geq 55$mmHg, pH ≥ 7.35, $PaC0_2 \leq 45$mmHg, (previous eucapnea) and f≤ 30 breaths/min in the presence of likely airway protection.
RESULTS: 222/242 elective extubations were successful. Failures were:

n=20/242(8.2%)	Cause
8 (40%)	stridor
5 (25%)	↑ respiratory rate, ↓ O_2
2 (10%)	↑ respiratory rate alone
2 (10%)	↓ secretion clearance
1 (5%)	↓ PaO_2 alone
1 (5%)	↑ $PaCO_2$ alone
1 (5%)	↑ respiratory rate, ↑ $PaCO_2$

CONCLUSION: The use of a CPAP/RA trial results in a low rate of extubation failures. Excluding the 8 patients sustaining unheralded stridor, reintubation was necessary in only 5%, with concurrent tachypnea and hypoxemia the primary cause. In contrast to traditional criteria, patient cooperation or effort is not necessary, minimizing variability and therefore standardizing outcome prediction.

OF-93-010R

COMPARISON OF TWO SURFACTANT REPLACEMENT DRUGS IN THE TREATMENT OF WOOD SMOKE INHALATION. Gary Nieman BS, Robert Fluck MS RRT, Andrew Paskanik, Tawfic Hakim PhD, and William Clark MD. SUNY Health Science Center, Syracuse, N.Y.

Introduction: Wood smoke inhalation (WSI) inhibits pulmonary surfactant function both directly (Respir Care 1992;37:1365) and secondarily by contamination of the alveolus with a protein rich edema. Therefore we treated dogs subjected to WSI by instillation of two surfactants [Infasurf (INFA) or Exosurf (EXOS)] and compared their therapeutic value. **Methods**: Mongrel dogs (n=16) were anesthetized, placed on a Bear 5 ventilator (40% O$_2$), and surgically prepared for hemodynamic and blood gases measurements; pulmonary shunt and compliance were calculated. At the conclusion of the experiment, lung samples were taken for lung water (wet/dry wt. ratio; W/D), dynamic surface tension (STmin), and morphometric analysis. Smoke was produced by burning a mixture of fir plywood sawdust moistened with kerosene and delivered with tidal ventilation for 5 min. The surfactants (INFA and EXOS, 100mg/Kg) or saline were instilled (IN) into the lung via suction catheter as the animals were rotated. **Protocol**: Following baseline measurements and WSI, dogs were separated into 4 groups: Group I-no intervention; Group II-Saline IN; Group III-EXOS IN; and Group IV-INFA IN. Data was collected post WSI for 4 hrs at which time the animals were sacrificed. **Results**:

Arterial Oxygenation (P$_a$O$_2$mmHg)

	Baseline	WSI+IN	4Hr post WSI
GpI	192±15	43±7	57±5
GpII	205±12	37±1	55±9
GpIII	202±24	56±8	66±6
GpIV	224±4	42±4	181±19*

(*=p<0.05 vs Groups I-III)

Only INFA instillation significantly improved PaO$_2$, shunt, compliance, and STmin 4 hrs following WSI. W/D was elevated in all groups. These data demonstrate that INFA but not EXOS instillation reestablishes surfactant function, inhibited by WSI, improving pulmonary compliance and oxygenation.

OF-93-036

PRESSURE SUPPORT VENTILATION (PSV): WEANING (W) RESULTS IN TWO DIFFERENT GROUPS OF PATIENTS (Pt)—Elizalde J, Franco J, Miranda R, Martinez J. ABC Hospital, Mexico DF. Mexico.

W from mechanical ventilation (MV) continues to be a problem in a specific group of Pt; PSV being one of the preferred W methods used in the last years, has not showed an advantage over more conventional forms. The aim of this study was to analyze the usefulness of PSV in difficult to W (DW) Pt and easily W (EW) Pt, comparing the results with T-piece trials. We prospectively studied 155 Pt: 80 EW (Group A) defined as MV<3 days, MIP>30, f/VT<50, and absence of COPD; and 75 DW (Group B)Pts defined as MV>3 days, MIP: 22-30, f/VT: 51-110, and presence of COPD. Randomization was done between the 2 W methods. PB 7200 and Bear 5 ventilators were used. End point to consider W success was to obtain full MV liberation for > 24 Hr. **Results:** $\bar{X}$ duration of MV was different between groups (A: 1.7±1.2 vs B: 8.9±3.7 days, p<0.01). Age was similar between groups (A: 59±13 vs B: 63±11 years). In Group A, there was no difference between $\bar{X}$ W duration or W failure between the 2 methods (1.6±0.5 vs 1.2±0.4 days and 4.7% vs 2.7% respectively). In Group B, $\bar{X}$ W duration was shorter with PSV while compared with T-piece (3.4±1.6 vs 6.9±2.0 days, respectively; p<0.05); and although there was a trend to a greater success rate in the W trial with PSV, there was not a statistically significant difference against T-piece (PSV: 73% vs T-piece: 64.7%, p=0.06). Cost analysis showed an advantage with PSV in group B, with $\bar{X}$ savings per patient of $3,500 USD in hospital charges (p<0.05), with no differences in Group A Pt. **Conclusions:** Method of W is not an important fact in EW Pt, but in the DW ones it seems that PSV would represent the method of choice in terms of W duration and costs, and is associated with lesser chances of final W failures when compared with traditional W techniques.

OF-93-048

DISTAL AIRWAY PRESSURE WITH A CLOSED-SYSTEM SUCTION CATHETER

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An advantage of a closed-system suction catheter (CSSC) is that patients are ventilated and oxygenated during the procedure. Little is documented of distal airway pressure with the catheter inserted. Our hypothesis was that distal airway pressure increases with the catheter inserted and the magnitude increases as endotracheal tube (ETT) size decreases or compliance (C) increases. **Method:** Pressure was monitored at the inlet and outlet of an ETT (Portex, Smith Indust. Med. Systems, Keene NH). Both lines were connected to a pressure monitor (Pneumogard 1600, Novametrix Med System, Wallingford CT). The ETT distal end was connected to a test lung (VentAid TTL, Michigan Instruments, Grand Rapids MI). The proximal end connected to a 14 French CSSC (TrachCare, Ballard Med Products, Draper UT) and a ventilator (7200, Puritan Bennett, Carlsbad, CA). The ventilator was set to VT=0.8 L, f=16, flow rate= 50 L/m (square wave; I:E of 1:3), pressure limit 15 cm H2O> peak inspiratory pressure (PIP). A #9, 8 and 7 ETT were used. The test lung C was set to both 20 and 60 mL/cm H2O. The following measurement were taken with the catheter out of and within the ETT: PIP, mean airway pressure (MAP), PEEP, and expired VT. Each condition was tested 10 times. **Results:** The ventilator pressure limited each breath with the # 7 and 8 ETT. Values for the distal pressure readings with the catheter out vs in the ETT are (mean ± SD; PIP, MAP, PEEP in cm H2O, VT in mL):

	PIP		MAP		PEEP		VT	
ET	out	in	out	in	out	out	out	in
7	21.5 ± 8.7	6.8 ± 2.2	6.6 ± 1.9	1.5 ± 0.5	0 ± 0	0 ± 0	893 ± 58	18 ± 4
8	21.0 ± 8.2	13.3 ± 5.6	5.7 ± 1.6	3.1 ± 1.4	.05 ± 0.2	.05 ± 0.2	882 ± 46	323 ± 90
9	21.0 ± 9.3	21.5 ± 9.8	5.4 ± 2.1	7.0 ± 2.4	0 ± 0	0.5 ± 0.5	887 ± 79	922 ± 64

	PIP		MAP		PEEP		VT	
C	out	in	out	in	out	out	out	in
20	29.7 ± 0.5	19.5 ± 9.3	7.7 ± 0.5	5.3 ± 3.1	0 ± 0	0 ± 0	828 ± 13	427 ± 350
60	12.6 ± 0.6	8.2 ± 3.1	4.1 ± 0.6	2.5 ± 1.6	.03 ± 0.2	0.4 ± 0.5	946 ± 18	414 ± 420

All catheter out vs in values for a given parameter were significant ($p<0.05$), except for PEEP. **Conclusion:** Although pressure limiting protects the patient from barotrauma, adequate ventilation may not occur. Care should be taken to ensure proper ventilation between suction attempts. When the full VT is delivered, distal PIP, MAP and PEEP increase—which will be more pronounced with a shorter expiratory time.

OF-93-097

COMPREHENSIVE PHYSIOLOGIC CHANGES, IN THE OPEN HEART PATIENT, DURING THE SIMPLE SUPINE TO LATERAL MOVE

M Kemper, BA, CRTT, D Cohen, MD C Weissman, MD, Columbia Presbyterian Medical Center, Departments of Medicine and Anesthesiology, New York, NY

Introduction: ICU pts are often turned from the supine to lateral position to facilitate care or procedures, such as CPT. Increases in metabolics and hemodynamics observed with the move, are often attributed to procedures rather than just the simple act of turning.[1] We studied changes in the metabolic, hemodynamic and blood gas parameters associated just with supine to lateral turning.

Methods: Thirteen stable, mechanically ventilated pts, less than 24 hours after coronary artery bypass were studied. Each had peripheral and pulmonary artery catheters. Metabolic, hemodynamic and blood gas values were all sampled simultaneously during an initial rest, with the pt supine, following a 2 min. turn to each side, and a final rest. The selection of which side to turn to first was randomly chosen. The PB 7200 was used to ventilate the pt. A validated, calibrated SensorMedic Deltatrac, which was interfaced according to manufacturers specifications, was used to measure metabolics. Hemodynamics were monitored with the Hewlett-Packard Merlin system. The study was conducted from 6:30AM to 10:30 AM.

Results: Values are mean ± SD

	Rest	Turn	Rest
VO_2 (ml/min)	219 (21)	324 (58)*	219 (21)
SVO_2 (%)	69 (6.6)	65 (9)*	71 (6)
V_{CO2} (ml/min)	180 (18)	260 (49)*	184 (16)
PaO_2 (Torr)	124 (18)	143 (27)	125 (21)
RR (min -1)	12 (5)	16 (7)*	13 (5)
HR (min-1)	84.8 (12.9)	93.2 (16.2)*	86.2 (12)
SBP mmHG	115 (13)	126 (24)*	112 (12)
ER	0.27 (.07)	0.32 (.09)	0.26 (.06)

* vs Rest - $p<0.05$

Discussion: Oxygen consumption and CO_2 elimination increased significantly. This was associated with an increase in respiratory rate, heart rate and systolic blood pressure. These patients had low hemoglobin levels (9.6± 1.2) and thus had high baseline oxygen extraction when completely at rest.

Conclusion: A simple supine to lateral turn alone, not associated with an additional procedure, can produce significant increases in metabolics and hemodynamics. Critically ill patients may have trouble adequately compensating for increases required during simple turns, especially if they are 24 hours after a CABG.

[1] Kemper M et al.: Resp. Care 37: 1313, 1992

OF-93-129

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CONTINUOUS NEGATIVE EXTRATHORACIC PRESSURE; AN UNUSUAL ADJUNCT TO WEANING FROM MECHANICAL VENTILATION.

J. M. Graybeal, CRTT, K. High, MD. Dept. of Anes. P.S.U., College of Medicine, Hershey, Pa. 17033

The use of Continuous Negative Extrathoracic Pressure (CNEP) via a Cuirass-style ventilator has been shown to increase FRC, in normal humans (Anesthesiology 65(3A):A83, 1986) and to cause minimal hemodynamic effect, in postoperative patients (Respiratory Care 33(10):956-7, 1988). We report the use of CNEP as an adjunct for weaning a 60 year old white female patient with chest wall instability following a left hemithoracectomy, with partial resection of ribs 2 through 8, due to metastasis of recurrent breast carcinoma. Immediately postoperatively, this patient was ventilated using a PB-7200a in the SIMV mode, and then was switched to Pressure Support (PS) with +5cmH2O CPAP. The patient tolerated this well and was able to have PS lowered to +10cmH2O. On postoperative day 8 an attempt to wean PS to 0cmH2O (with +5cmH2O) was unsuccessful. Arterial blood gases (ABG) prior to weaning were pH=7.49, paCO2=35.2, paO2=86 on an FiO2=0.50. The patient rapidly became tachycardic, hypertensive and diaphoretic. The weaning process was stopped after 10 minutes, ABG were pH=7.15, paCO2=84.5, paO2=83, on FiO2=1.0. Following return to PS the patient returned to baseline. During this weaning attempt an increase in left-sided chest wall instability was noted. In a compassionate effort to wean and extubate this patient, a trial of CNEP using a prototype Cuirass-style vest (Respironics, Inc) was begun. An initial 10 minute trial of 20cmH2O CNEP with +5cmH2O CPAP was well tolerated. The patient was then placed on 20cmH2O CNEP plus t-piece with FiO2=0.50 for 2 hours, which was also well tolerated (see table below). At the end of 2 hours the patient's ABG were pH=7.44, paCO2=38.7, paO2=67 on FiO2=0.50. The patient was successfully weaned from PS and extubated. CNEP therapy was weaned over the next 4 days prior to discharge from the ICU. This case demonstrates the use of CNEP as an adjunct for weaning patients with chest wall instability from mechanical ventilatory support.

Table

Time (min.)	0	20	60	120
SaO2 (%)	94	93	92	93
petCO2 (mmHg)	33	31	31	30
HR (bpm)	72	83	88	82
RR (bpm)	22	24	26	23
BP mean (mmHg)	72	97	86	77
CVP (mmHg)	23	25	14	13
Vt. (ml) spont.	450	450	420	480
Ve (liters) spont	9.7	10.4	10.1	10.1

OF-93-155

INDEPENDENT LUNG VENTILATION (ILV) FOLLOWING SINGLE LUNG TRANSPLANT (SLT).

William Anton BA RRT, Richard Albert MD, David Ralph MD, Thomas Marchiaro MD, Douglas Wood MD, Ganesh Raghu MD, UWMC,Seattle.

Significant disparity of V/Q between the left (L) and the right (R) lungs may result in poor oxygenation and/or ventilation following SLT. Since selective ventilation to individual lungs may overcome this problem, we applied ILV in 6 pts. post-transplant who had inadequate oxygenation with conventional ventilation (SLT n = 5, Double LT, DLT, n =1) [SLT, 4 COPD, 1 veno-occlusive disease, pt. #5; DLT, 1 pulmonary fibrosis, pt. #6]. Two Siemens 900-C ventilators provided independent frequency, tidal volume, and/or PEEP, via a double-lumen ET tube.

pt.	PO2*	PCO2*	CO+	BP**
1.BEFORE ILV	86	38	2.6	88
AFTER ILV	194	43	2.6	92
2.BEFORE ILV	61	44	4.3	115
AFTER ILV	298	47	4.5	112
3.BEFORE ILV	96	68	5.2	125
AFTER ILV	254	47	4.5	140
4.BEFORE ILV	74	46	6.1	90
AFTER ILV	164	35	6.2	108
5.BEFORE ILV	90	42	3.6	100
AFTER ILV	83	37	4.2	110
6.BEFORE ILV	53	49	5.2	90
AFTER ILV	62	65	7.2	110

* torr, + cardiac output,
** systolic (mm Hg)

Conclusion: ILV improves oxygenation following SLT in patients with significant differential lung compliance, and does not adversely affect the hemodynamic status.

OF-93-165

COMPARISON OF PRESSURE SUPPORT AND PRESSURE SUPPORT WITH FLOWBY COMBINATION USING A WEANING PROTOCOL IN THE CARDIOVASCULAR RECOVERY ROOM; Hernando Mesina RRT, Doug Sabau RRT, Wadie Williams RRT, Elizabeth Bearden RRT, Joy Hargett RRT, John Sabo RRT; St. Luke's Episcopal Hospital, Houston, Texas

Study Question: Does the combined use of Pressure Support (PS) with Flowby (FB) enhance weaning from mechanical ventilation compared to PS alone. **Method:** Our institution has instituted a standard weaning protocol used in our cardiovascular recovery room (CVRR). The protocol defined eligibility, postoperative stages, clinical interventions, and analyzes cardiovascular status, ABGs, NIF, and VC. SIMV, CMV, PS, and FB are included in the weaning process. A control group using the standard protocol was compared to an experimental group using the Flowby 2.0 option (Puritan Bennett, Carlsbad, Ca) on the 7200 ventilator which allows FB to be active with PS and during CMV ventilation and allows breaths to be flow-triggered vs pressure triggered. We studied post-op coronary artery bypass (CAB) pts only. Excluded from the group were pts who currently smoke or had a smoke free history of < 5yrs. Also excluded were pts requiring balloon pumps. The control group consisted of 29 pts and the experimental group consisted of 23 pts. Weaning time was calculated starting with the pt's admission to the CVRR until extubation. **Results:** Analysis by t-test indicated no significant difference in mean ventilator time in Ps only vs PS and FB (10.91 and 12.22 hrs respectively). PaCO2 and PaO2 were similar during both modes of weaning, pH was higher in the PS mode only. Spontaneous ventilatory parameters did not differ significantly among the different modes, though findings revealed slight increases in VT in PS with FB group (11.5%). An incidental finding revealed eligible extubations may be delayed (increased wean time) due to the time of day; fewer pts extubated between 12MN and 6AM (15 pts after 12MN vs 37 pts after 6AM, 29% for combined population). This is related to the protocol requirement that the Anesthesiologist be present to extubate the pt. **Summary and Conclusion:** There was no clinically significant difference between the two groups. Expected, clinically desired pt outcomes were not adversely affected by the use of either ventilatory method. A larger scale clinical trial is suggested and different cardiovascular surgical diagnosis should be included.

OF-93-187

EFFECTS OF CHEST WALL VIBRATION IN LUNG SURGERY PATIENTS. Tetsuo Miyagawa RPT, RCE, RRT, Kazuyoshi Fukai RPT, Kunisato Miyoshi MD, Hiroaki Osada MD. St. Marianna Univ. School of medicine Hospital, Kawasaki, Japan. Ikuo Homma MD. Showa Univ. School of Medicine, Tokyo, Japan.

Introduction:Homma et al. have been reported that vibration of the upper chest wall during inspiration and the lower chest wall during expiration(in-phase-CWV)caused a increase of V_T. The purpose of this study was to evaluate the effects of in-phase-CWV for lung surgery patients. Method:The subjects were 14 patients with lung surgery(mean age 60.9±11.4yr). Operative proceduces employed were lobectomy in 10, pneumonectomy in 3, and thymectomy in 1 patients. Subjects were given in-phase-CWV for 5 mins and diaphragmatic breathing for 5 mins on POD#1. Eccentric disc vibrators enclosed in small cylinders were placed on the 2nd parasternal intercostal space(upper), and the 7th intercostal space on the anterior axillary line(lower). Vibration frequency was 100 Hz. We measured expired gas by Aeromonitor RM 300i(Minato Medical Inc, Tokyo), SvO_2 and PAP by Opticath P7110(Oximetrix Inc, Ohio), SpO_2 by Pulse oxymetry 503(Criticare Systems Inc, Milwaukee). And we evaluated ABG before and after in-phase-CWV and diaphragmatic breathing. Deta were compared by paired t-tests, $P<0.05$ was considerd significant. Results:Deta obtained are tabled at the bottom. There was significant difference betweeen resting breathing and in-phase-CWV or diaphragmatic breathing. However, there was no difference betweeen in phase CWV and diaphragmatic breathing. Significants improvement in pri- and post PaO_2(90.7±30.8torr vs 101.9±40.3 torr, $p<0.05$) was obtained. Conclusion:In--phase-CWV seemes as effective as diaphragmatic breathing, as for increasing postoperative V_T. And in-phase-CWV may be effective for prophylactis of postoperative complication.

	rest	in phase CWV	dia. breath
V_T(mℓ)	487.8 ± 128.5	$591.7\pm160^{**}$	$619.1\pm156.7^{**}$
RR(breaths/min)	19.0 ± 3.6	$16.6\pm4.1^{**}$	$15.6\pm4.3^{**}$
V_T/T_I(mℓ/sec)	413.2 ± 112.9	415.1 ± 97.2	409.7 ± 122.1
T_I/T_{TOT}	0.38 ± 0.03	$0.4\pm0.04^{*}$	$0.4\pm0.04^{*}$
$ETCO_2$(%)	4.43 ± 0.63	4.40 ± 0.52	4.60 ± 0.72
V_D/V_T	0.46 ± 0.05	0.46 ± 0.04	0.45 ± 0.04
VO_2(mℓ/min)	192.1 ± 52.0	196.9 ± 42.6	201.1 ± 47.5
VCO_2(mℓ/min)	146.5 ± 42.7	$157.4\pm35.3^{*}$	$158.2\pm41.4^{*}$
SpO_2(%)	93.6 ± 3.1	$95.1\pm2.5^{**}$	$95.0\pm2.5^{**}$
SVO_2(%)	73.3 ± 9.2	$75.0\pm9.4^{**}$	$75.0\pm8.8^{**}$
PAP(mmHg)	16.8 ± 3.9	$15.5\pm3.8^{*}$	$14.9\pm3.5^{*}$

$^{*}p<0.05$, $^{**}p<0.01$

OF-93-213

NOCTURNAL "HIGH FLOW" AUGMENTED VENTILATION (TTAV) IMPROVES EXERCISE CAPACITY IN PATIENTS WITH SEVERE LUNG DISEASE.

D. Theron Van Hooser M Ed., RRT, Susan Jorgenson RN ,MSN , Les Winslett, CRTT, RPFT, Don Conner, RRT, Kent Christopher, RRT, M.D. Vencor Hospital and Swedish Medical Center, Denver, CO.

Introduction: In an animal model we have shown that high transtracheal flows of an air/oxygen mixture actually augment ventilation (TTAV) without the use of standard techniques for ventilatory support. Anecdotal experience in 2 patients with end-stage COPD suggested that nocturnal TTAV improved daytime functional capacity. The purpose of this study was to determine if nocturnal TTAV improves exercise capacity in patients with severe lung disease. **Methods:** Fifteen medically stable outpatients with severe lung disease and chronic hypoxemia were evaluated. Upon entry, each subject had been receiving transtracheal oxygen and had a mature tract. Institutional Review Board approval was obtained. Maximal graded treadmill exercise study was performed. Each subject breathed an oxygen enriched gas mixture via a mouthpiece and noseclip (without transtracheal delivery). Duration of exercise (seconds) and total work (joules) were calculated. Patients then received nocturnal TTAV for 2 1/2 -3 months. Each night, TTAV was delivered at 8 to 12 L/min at .40 -.70 FIO2 via standard liquid oxygen reservoir interfaced with a customized air compressor operating at 23 PSI (Bird Medical Products, Palm Springs, CA) . A servo humidifier (Bird Life Design, Carrillton, TX) delivered transtracheal gas to the patient. Standard low flow transtracheal oxygen was administered during the day. At the end of the study, the maximal graded treadmill exercise study was repeated in a similar fashion. **Results:** Mean exercise time was significantly increased($p<.05$) when comparing the pre(471.1 ± 50.4 sec) to post treatment periods(826.2±104.9 sec). Likewise, mean work was significantly lowered ($p<.05$) when pre treatment (1,199±398 joules) data were compared to post treatment conditions(2,059±454 joules). Results correlated with an anecdotal improvement in the patients' activity level. **Conclusions:** Nocturnal use of TTAV may improve exercise capacity and functional capabilities of patients with serve lung disease.

OF-93-021R

COMPARISON OF TRANSTRACHEAL AUGMENTED VENTILATION (TTAV) WITH CONVENTIONAL T-PIECE WEANING.

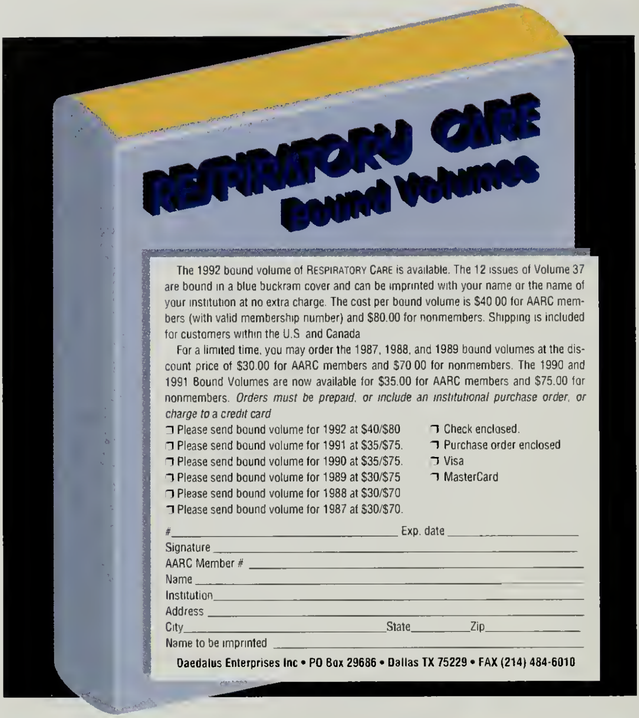
D. Theron Van Hooser M.Ed, RRT, Susan Jorgenson MS, RN, Les Winslett, CRTT, RPFT, Kent Christopher, RRT, MD, Vencor Hospital and Swedish Medical Center, Denver, Colorado.

Introduction: Use of a secondary (bias) flow into the airway from a transtracheal catheter as a weaning technique has not been described. We speculated TTAV could be used safely and effectively as conventional T-Piece weaning. **Methods:** Eleven ventilator dependent patients with multiple wean failures were selected for study. Nine had diagnosis of COPD, one had post polio syndrome and one had muscular dystrophy. Total number of days on mechanical ventilation upon entry was 1,290. IRB approval was obtained. Each patient was initially weaned with Pressure Support Ventilation (PSV) down to a pressure of 6 cm using a Shiley size 7 or 8 tracheostomy tube (7-8PSV). ABG's and respiratory rate (RR) were then assessed under the following four conditions: 1) 7-8PSV and, 2) Conventional T-Piece trial with the same tube (7-8TP), 3) PSV with a Shiley #4, fenestrated cuffed tube (4PSV) utilizing a pressure support setting to achieve similar volumes to 7-8PSV and, 4) TTAV. During TTAV, a transtracheal oxygen catheter (Transtracheal Systems, Englewood, CO) was placed within the lumen of a Shiley #4 fenestrated cuffed tracheostomy tube using a modified button (4TTAV). A humidified air/oxygen mixture was delivered through the transtracheal catheter at 10 L/min via a heated wire circuit from a servo-controlled humidifier. **Results:** RR was significantly reduced with TTAV compared to other modes ($p <.05$). A comparison of pH, PaCO2, SaO2 and PaO2 collected during all 4 modes showed no significant difference:

	PaO2	PaCO2	pH	SaO2	RR
7-8PSV	82.0±6.1	47.5±3.9	7.43 ±.01	2.6±.91	25.41±1.6
7-8TP	100±11.3	52.5±2.9	7.38±.02	93.9±0.82	27.4±1.8
4PSV	88.1± 7.9	48±3.1	7.41±.02	93.2±.9	24.1±2.1
4TTAV	77.6±3.7	51±3.3	7.39±.01	92.9±0.52	19.4±1.8

Experience: 7 patients were weaned from 4PSV to 4TTAV, then to low flow transtracheal oxygen. Of the remaining patients, 1 went back to mechanical ventilation because of psychological dependence. One patient had progressive neuromuscular disease that required nocturnal ventilation, and weaning was terminated in 2 patients due to acute non pulmonary compromise. All eleven patients preferred 4TTAV to 7-8TP. **Conclusions:** We conclude in this population, TTAV is as safe and effective as T-Piece weaning. Patients are able to speak. COPD patients regained their glottis as a variable regulator of expiratory air flow. TTAV also reduces RR. The ability to communicate appeared to have improved the patients' attitude and self-image and this factor may have played a role in decreased weaning times.

OF-93-022R



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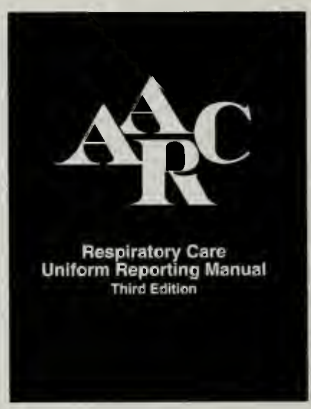

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A MULTI-FUNCTIONAL TRACHEOSTOMY TUBE FOR LONG TERM CARE

John Hoppough, RRT, Jack Kunst, RRT, CPFT. Metropolitan Hospital, Grand Rapids, Michigan

Tracheostomy tubes are standard devices used to access the airway. Modifications are, at times, necessary to address the needs of certain patients. We implemented a procedure to meet the special needs of a post-polio patient. She required an uncuffed tracheostomy tube with a 15 mm adaptor for her ventilator assisted breathing periods and a fenestrated tube during her non-assisted periods. She could not tolerate breathing solely through her upper airway. She desired to phonate clearly with minimal effort as well. Her cough effort was weak and the tracheostomy provided for adequate pulmonary hygeine. She was admitted to our facility for rehabilitation. During her stay, we obtained a Jackson tube with a 15 mm adaptor on the inner cannula and had the outer tube and inner cannula fenestrated at the standard position. We also obtained a second, non-fenestrated inner cannula with a 15 mm adaptor. Instruction was given to use the non-fenestrated inner cannula for ventilator assisted periods and the fenestrated inner cannula for spontaneous breathing periods. During the spontaneous periods, a Portex Thermovent T was placed on the 15 mm adaptor, and she could easily phonate by manually occluding the side T ports. This protocol addressed the needs of this patient. She was discharged to her home and is doing well. The one time cost for the Jackson tracheostomy tube was $264.00. Disposable tubes are approximately $45.00 each and require routine replacement monthly ($540.00/yr). The multi-functional, non-disposable tracheostomy tube can provide a cost-efficient and clinically appropriate method for the long term management of patients with these special needs.

OF-93-027

FUNCTIONAL INDEPENDENCE MEASUREMENT BEFORE AND AFTER PULMONARY REHABILITATION

Pam Marsh, BS, RRT, Wendy Combs, OTR, Baylor University Medical Center, Dallas, Texas

INTRODUCTION: Our Pulmonary Rehabilitation (PR) Program recognized the need for more objective measurement of functional independence to perform activities of daily living (ADL). We designed a pre-post program with evaluation of functional independence to perform ADL that is both objective (therapist assessment and pulse oximetry) and subjective (Borg scale of perceived exertion). Objective measures of capacity to perform ADLs and knowledge of work simplification techniques provide the therapist with information on the patient's (pt) functional level and on training and education required during PR. At completion of PR the therapist and pt should have a tool to assess progress toward returning pt to highest level of functional independence. **METHOD:** At initial evaluation (IE) for PR pt is evaluated for knowledge level and physical ability by three mechanisms: (1) therapist's assessment of tolerance to perform ADLs, (2) pt's perception of dyspnea [Borg scale] and (3) pulse oximetry. The pt performs three or four activities in each of three tolerance levels: minimum tolerance level (i.e., combing hair), moderate tolerance (i.e., putting on shoes), and maximum tolerance (i.e., climbing stairs). At IE pt is not instructed on appropriate way to perform the activity. During PR pt is instructed in controlled breathing technique, energy conservation, and attends a skills lab on performing the activity correctly and participates in 18 structured exercise sessions, designed to enhance strength and endurance. After PR, pt is re-evaluated using the same criteria. **RESULTS:** Our preliminary findings based upon evaluation of the first five pts showed 60% of pts demonstrated an increase in tolerance level while performing the activity in all three categories; 20% demonstrated an increase in tolerance in only one category; and 20% had no change in tolerance. Perception of dyspnea was decreased in 60% of the pts and there was no change in the other 40%. O_2 saturation increased in 20% of pts (avg. increase 3%) and there was no change in the other 80%. **CONCLUSION:** Based on this sample size, functional independence measurements provide objective data to determine outcomes and positive impact of PR on most pts lives. It can be used as a tool to educate physicians, third party payors, and Medicare on benefits of PR. Based on these results, the study is continuing.

OF-93-040

ASTHMA SELF-MANAGEMENT SKILLS PROGRAM CAN REDUCE EMERGENCY DEPARTMENT VISITS AND HOSPITALIZATIONS,

Gretchen Lawrence, BA, RRT, Baylor University Medical Center, Dallas, Texas

We compared asthmatic patients' related emergency department (ED) visits and hospitalizations (HOS) for the 12-month periods immediately before and after treatment in our center. All patients received physician directed medical management based upon the National Asthma Education Panel recommendations. One group (N = 13) received instruction in self-management using the peak flow meter (PFM) and an action plan (AP) to adjust medication dosages in response to changing post-bronchodilator peak flow meter readings. Average cost for this intervention was about $250 (two visits with 60" to 90" instruction). The other group (N = 14), in addition to receiving a PFM and AP, completed a multidisciplinary education program which stressed trigger identification and avoidance, environmental control, proactive adjustment of anti-inflammatory agents and stress management. Average cost for this intervention was about $850 (multidisciplinary evaluations and 12 hours of instruction). Those who did not enter the educational program did so by choice or circumstances (i.e., transportation problems, inability to commit the required time for the program, insurance denial). Of the PFM and AP only group, 8 of 13 accounted for the 31 ED and/or HOS pre-admission. Four of 13 accounted for the 15 ED and/or HOS after discharge (50% improvement). Of the group who attended the educational sessions, 7 of the 14 accounted for 25 ED and/or HOS pre-admission. There were no ED and/or HOS after the program (100% improvement). Based on this sample population, it is evident that while receiving PFM and AP does improve asthma management, an educational program that addresses overall understanding of the disease process and trigger avoidance can significantly impact the overall cost of care, both monetarily and emotionally.

OF-93-044

QUALITY OF LIFE VARIABLES INFLUENCED BY OUTPATIENT PULMONARY REHABILITATION

By: Joanne Bryant, RN,CCRN; Christopher Pamp, M.ED: Mark Devereux, RRT. General Hospital Medical Center, Everett Washington.

The hypothesis is that Pulmonary Rehabilitation (PR) assists COPD patients improve their quality of life. Eighteen COPD patients (6 female, 12 male; mean age 66.3) completed a PR consisting of initial evaluation, supervised exercise, education (each 3 times per week for 8 weeks), and discharge evaluation. Prior to the advent of the program, several outcome measures were chosen to measure patient improvement with a focus on quality of life. These measures are: 1) 6 minute walk test (6WT), 2) the Chronic Respiratory Disease Questionnaire (CRQ), and 3) the Beck Depression Inventory (BDI). These tools are administered with patient's consent within one week of program entry, and within one week of program completion. The results of the before-after study are treated statistically as the standard error of the difference between means for correlated groups. In this case, it is presumed that each patient will remain consistent with her/himself; thus there will be a correlation between the before and after PR sample.

Results:	before	after	correlation
Mean 6WT	845ft	1084ft	(p<.05)
CRQ fatigue	14	19	(p<.01)
CRQ emotional	30	36	(P<.05)
CRQ mastery	16	23	(P<.001)
BDI score	10.4	8.5	(p<.1ns)

6WT improvement is attributed to improved cardiorespiratory endurance due to aerobic training, breathing techniques learned in education, and decreased anxiety. CRQ improvements in dyspnea and fatigue also are due to aerobic conditioning, while improvements in mastery and emotional function may be attributed to the educational series, improved self esteem, and peer interaction. Failure of BDI to improve significantly despite a trend toward improvement should not be interpreted to imply that PR is not useful with depressed patients; significant change in depression may develop over time with lifestyle improvement. This PR has positively influenced several quality of life variables of participants, thereby enhancing day-to-day activities and potentially reducing admissions. OF-93-095

THE EFFECTS OF ACTIVE CYCLE BREATHING TECHNIQUES (ACBT) ON HEART RATE AND PULSE OXIMETER SATUATION (S_pO_2) IN CYSTIC FIBROSIS PATIENTS

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David M. Habib, MD[1,2]
Departments of Respiratory Care[1] and Pediatrics[2], Medical University of South Carolina, Charleston, South Carolina.

Active cycle breathing technique (also known as forced expiratory maneuver) is a patient mediated pulmonary therapy consisting of a number of relaxation techniques, breathing exercises, and airway clearance procedures. In our experience anecdotal evidence has suggested an associated increase in secretion clearance, improved aeration, lowered post treatment HR, and increases in post treatment S_pO_2 in CF patients treated with ACBT. In order to test the hypothesis that significant improvement in HR and S_pO_2 are associated with ACBT, a retrospective study of a convenient sample of (24) CF patients (ages 8-36 years, mean 21 yr.) who were treated with ACBT in our outpatient clinic was undertaken. Data are shown below:

	HR			S_pO_2		
	Pre	Post	▲	Pre	Post	▲
$\overline{X}$	107.4	96.08	-10.96	91.38	94.33	2.96
SD	18.53	19.74	12.36	5.70	3.98	3.22
p	< .001			< .001		

Statistical significance was obtained by two tailed, paired t-test and the mean change for both HR and S_pO_2 were found to be very highly significant ($p < .001$). We conclude that ACBT may offer an effective alternative in the treatment of cystic fibrosis. Further research in a controlled multicenter study is now underway to identify the exact methods of action, evaluate the effectivness of ACBT in comparison to other existing therapies, and to identify possible applications in other pulmonary disease states.

OF-93-151

AARC Videoconferences

Arterial Blood Gas Trouble Shooting: Interpretation, Analysis, and Quality Control

July 26: 12:30 p.m. to 2:00 p.m. Eastern Time (One CE Credit)

This session defines the current "state-of-the-art" in blood gas analysis as well as the advantages and disadvantages of traditional laboratories, point of care testing, and in vivo monitoring. Viewers will learn trouble shooting techniques, interpretation, analysis, and quality control. Dr. Shapiro will also review the impact of CLIA regulations on quality control issues and discuss the costs and appropriate usage of resources.

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AARC Videoconferences

The New Ventilator Management: Permissive Hypercapnia and other Variations on Conventional Mechanical Ventilation

November 8: 12:30 p.m. to 2:00 p.m. Eastern Time (One CE Credit)

This session will outline the new techniques and theories surrounding mechanical ventilatory support. Dr. MacIntyre will discuss the use of pressure limited ventilation and the role of reduced peak pressure on prevention of lung damage. New endpoints for therapy will be described with special reference to the use of permissive hypercapnia. Also reviews weaning with emphasis on the imposed work of breathing and options for its elimination. Dr. MacIntyre will conclude with a discussion of what features the next generation of ventilators should possess.

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PERIOPERATIVE INHALED CARBON DIOXIDE ADMINISTRATION IN PATIENTS UNDERGOING NORWOOD STAGE I PROCEDURE FOR HYPOPLASTIC LEFT HEART SYNDROME.

LJ Miller BS RRT, SC Hillier MB ChB, D Chriscinske RRT. James Whitcomb Riley Hospital for Children, Indianapolis, Indiana.

The Norwood Stage I procedure has improved the outcome of infants with Hypoplastic Left Heart Syndrome (HLHS). In the peri-operative period the right ventricular cardiac output is directed into both the systemic and pulmonary circulations. However, because the pulmonary vascular resistance (PVR) is low compared to the systemic vascular resistance (SVR), pulmonary blood flow (PBF) is increased at the expense of decreased systemic blood flow (SBF). Peri-operative strategies to improve SBF include maneuvers to increase PVR. In order to increase PVR without the adverse effects of PEEP on SBF, we ventilated 3 infants with an adjustable mixture of CO_2 and air, using 12-16 ml/kg tidal volumes and 0.75-1.0 sec inspiratory times. The addition of between 5-18 mmHg inspired CO_2 maintained $PaCO_2$ at 35-45 mmHg despite large minute volumes. With an FiO_2 of 0.21, and complete intracardiac mixing of PBF and SBF, a PaO_2 of 40 mmHg indicated an appropriate balance of SBF and PBF. Blood pressure, skin perfusion, urine output, and base deficit were also used to monitor SBF during the weaning of CO_2 and ventilatory support. Of these 3 patients, 2 were discharged from the hospital, and one died. However, the previous 5 patients with HLHS prior to the use of inhaled CO_2 all died as a direct result of inadequate SBF.

OF-93-005R

INHALED NITRIC OXIDE: A BRIDGE TO ECMO

Peter Betit RRT, Ian Adatia FRCP(C). Children's Hospital, *Boston, Massachusetts.*

Inhaled Nitric Oxide (NO) is reported to be a selective and effective pulmonary vasodilator (*Circulation* 1992;86:I-776). This therapy may be particularly beneficial in the management of persistent pulmonary hypertension of the newborn (PPHN) (*Lancet* 1992; 340:818-20). We report the use of NO in a neonate who was referred to our institution for management of PPHN. Echocardiography demonstrated normal intracardiac anatomy, pulmonary hypertension and right to left shunting at the foramen and ductal levels. An unsuccessful trial of high frequency oscillatory ventilation (HFOV) with the SensorMedics 3100A was instituted (FiO_2-1.0, MAP-24 cmH_2O, f-15 Hz, amplitude-86 cmH_2O).Pressure control ventilation (PCV) with the Servo 900C was then attempted (FiO_2-1.0, f-60, PIP-30 cmH_2O, PEEP-4 cmH_2O, MAP-20 cmH_2O). During preparation for ECMO the patient was given a trial of NO at 80 ppm. NO and nitrogen dioxide levels were continuously analyzed by chemiluminescence. Exhaled gases were scavenged by wall vacuum. Oxygen saturation (SpO_2) improved immediately from 83% to100%. Discontinuing NO resulted in a decrease in SpO_2 to 85%. ECMO cannulation was prolonged due to technical difficulties and NO was restarted.

Blood Gas Values

	PaO_2	$PaCO_2$	pH
HFOV	43	20	7.70
PCV	36	23	7.65
PCV+NO#1	256	18	7.69
PCV+NO#2	195	13	7.69

Our experience suggests that NO therapy may provide a bridge to ECMO. Prolonged therapy may eliminate the need for ECMO in selected cases. However, further studies are warranted.

OF-93-060

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NITRIC OXIDE DELIVERY SYSTEM FOR SPONTANEOUSLY BREATHING PATIENTS

John Newhart RCP CRTT, F Wayne Johnson RCP CRTT RCPT, Richard N. Channick MD..

Introduction: We have developed a system for delivering nitric oxide (NO) to spontaneously breathing subjects. The use of NO as a potent vasodilator has been described in the literature (Circulation 1991;83:2038) when administered to spontaneously breathing subjects. Method: Our system was tested with subjects with a diagnosis of primary pulmonary hypertension (PPH). Nitric oxide (EPA Protocol 1 ± 1%, 500 PPM) and balance nitrogen (N2) were blended with pure nitrogen utilizing a special stainless steel (SS) blender (Bird Corporation, Palm Springs, CA). The blender output was connected to the air intake of a Bird 3800 blender. The NO N2 mixture was blended with oxygen (O2) inside the 3800 blender and delivered to the subject as a NO N2 O2 . The mixture was delivered via high pressure tubing to the inspiratory demand valve of the Scott Pressur-Vak II mask (Scott Aviation Lancaster NY.). Expired gas exits the mask via a pressure sensing valve that opens with exhalation allowing exhaled gas to be drawn into the hospital vacuum system via suction regulator. Inspired gas was analyzed by diverting sample gas from a second outlet on the 3800 blender. The sample stream is analyzed for O2 and NO concentration. An on-line 8840 chemoluminescence analyzer was used to measure concentrations of inspired NO and nitrogen dioxide (NO2) continuously. The remaining sample gas was collected via a Boeringer scavenger interface (Boeringer Laboratories Norristown, PA.) connected to wall vacuum. To achieve the precise NO N2 O2 mixture requires adjustment of the SS and 3800 blenders. A calibration table was developed to control NO N2 O2 concentration. Results: Desired concentrations of NO, N2, and O2 were delivered to the subjects without exceeding OSHA Environmental Standards for NO, and NO2 (Time weighted average 25 PPM/8 hr's NO, 1 PPM/8 hr's NO2).Conclusion: 40 PPM of NO can be effectively delivered, continuously analyzed and safely scavenged during spontaneous breathing. With this system and a 500 PPM NO source, a maximum FIO2 of .89 at 40 PPM can be delivered. A higher FIO2 would necessitate a higher concentration NO source gas.

OF-93-084

Chemiluminescent Analyzer Alters Nitric Oxide Delivery Concentrations

—Chris C Miller BA RRT, John WR Miller BS, Roseanne Bates RRT, Bruce Murrey BS, Doug Swanton RRT. University of British Columbia; St. Paul's Hospital, *Vancouver, Canada.* California Coast University, *Santa Anna, California.* Royal Alexandra Hospital. *Edmonton, Canada.*Children's Hospital, *Denver, Colorado.*

Introduction: The use of inhaled nitric oxide (NO) as a selective pulmonary vasodilator is expanding rapidly into anesthesia and critical care practice (Anes 1993;78:413). Sidestream chemiluminescence analysis (SCA) developed for industrial use is the "Gold Standard" currently used to measure and verify the delivered dose of NO; which is between 8-80 parts per million (ppm). Homogenous mixing of NO in the inhaled gases may be necessary for accurate measurement with sidestream technique due to the 1000 mL , min^{-1} flow requirement. We attempted to study the effects of SCA on the delivered NO concentrations in an inspiratory circuit of a continuous-flow-pressure-limited neonatal ventilator. **Method:** A conventional disposable inspiratory limb of a neonatal ventilator circuit was spliced in three equal positions with T-piece Briggs adapters to accommodate the three analyzer sampling positions. In relation to the inspiratory flow source of the ventilator, sampling positions were labeled proximal, neutral, and distal respectively. A calibrated mainstream electrochemical NO analyzer (MEC) was used for the study (Pulmonox I, Pulmonox R & D, Canada). The MEC was verified for accuracy through random comparisons to a calibrated SCA (Model 42, Thermo Environmental, USA) by interchanging each analyzer at the neutral position for NO concentrations between 5-80 parts ppm (n= 65; R=0.997). Measurement comparison sets (NO concentrations of 5,10,20,30,40,60,and 80 ppm) were recorded with the SCA at the neutral position and the MEC at either the distal or proximal sampling sites. Measurements were repeated at flow rates of 9, 10, 11, and 12 L , min^{-1}. **Results:** All NO concentrations were as much as 5% (± 4ppm) lower when the MEC was positioned downstream of the SCA at the distal site and these results were unaltered by changes in flow rates. There was no significant difference in measurements between SCA and MEC when MEC was in the proximal position for any of the NO concentrations and flows 0.2% (± 1ppm). **Conclusion:** Sidestream chemiluminescence measurement affects desired dosage of downstream delivery of NO by drawing off large sample volumes for analysis. Clinicians need to be aware of this fact. Mainstream analyzers and standardized NO gas delivery systems need to be developed for accurate dosage delivery of inhaled NO to the ventilated patient.

OF-93-131

Nitric Oxide Electrochemical Analysis Is Accurate and Cost Effective— John WR Miller BS, Roseanne Bates RRT, Bruce Murrey BS, Chris C Miller BA RRT. California Coast University, *Santa Anna, California.* Royal Alexandra Hospital, *Edmonton, Canada.* University of British Columbia, St. Paul's Hospital, *Vancouver, Canada*

Introduction: Chemiluminescence analysis for measurement of oxides of nitrogen is being used to verify inhaled nitric oxide (NO) dosage (Respir Care 1992;37:1175). These instruments have been designed primarily for industrial use not clinical use. Cost, physical size, tendency for sample line blockage and noise factor make these instruments less than ideal for clinical application. Electrochemical method of analysis has been a suggested alternative for NO measurement (Lancet 1992;340:1167). We designed this study to evaluate the accuracy of electrochemical NO analysis compared to chemiluminescence NO analysis. **Method:** The inspiratory limb of a disposable neonatal ventilator circuit was spliced with a T-piece adapter to provide a sampling position. NO gas from a 800 parts per million (ppm) source tank, through a low flow rotometer, was titrated into the inspiratory limb approximately 12 in upstream of the sampling site. Ventilator flows (8-12 $L \cdot min^{-1}$), FiO_2 (0.21-1.0), and NO concentration (0-100 ppm) were randomly altered with the ventilator in CPAP mode (0.0 cmH_2O). NO values were recorded when the digital values on the chemiluminescence analyzer remained stable for 30 s. The sampling line of the chemiluminescence analyzer was then replaced at the same site with the mainstream electrochemical analyzer sensor and the NO value was recorded when the digital values remained stable for 30 s. The sampling line of the chemiluminescence analyzer was exchanged back to the original set-up and we verified that NO was the same as the first measurement. This protocol was observed for all data collection sets. A calibrated electrochemical NO analyzer (Pulmonox I, Pulmonox Research & Development, Canada) and a calibrated chemiluminescence analyzer (Model 42, Thermo Environmental, USA) were used for the study. Paired student *t* test was used for statistical analysis with significance placed at $p<0.05$. **Results:** There was no significant difference in measurements between the electrochemical and chemiluminescence analyzers ($p<0.001$). **Conclusion:** Mainstream electrochemical analysis is as accurate as chemiluminescence analysis for verifying delivered NO concentration levels. Mainstream electrochemical analysis is approximately 75% less expensive, does not create any noise, and is physically small and easy to use.

OF-93-132

HYPOXIC GAS MIXTURE IN THE TREATMENT OF HYPOPLASTIC LEFT HEART SYNDROME:A NEONATAL CASE STUDY

Cynthia Malinowski, M.A., R.R.T., Loma Linda University, Assad, Assad, M.D., Loma Linda University Medical Center, Patrice Johnson B.S., R.R.T., Loma Linda University

Newborns with hypoplastic left heart syndrome (HLHS) can survive with orthotopic cardiac transplantation but due to the limitation of donors, may have a long waiting period prior to surgery. While awaiting transplantation, these patients often have difficulty with adequate systemic perfusion and pulmonary edema due to increased pulmonary blood flow at the expense of systemic blood flow. We report on the use of FI02's less than .21 to induce pulmonary vasoconstriction, increase systemic perfusion and resolve pulmonary edema. Case summary: A 3991 gram term female, born by normal vaginal delivery received echocardiography which revealed findings consistent with HLHS. She was placed on a prostaglandin E_1 drip to maintain patency of the ductus arteriosus. At one day of age a room air arterial blood gas revealed a pH of 7.41, PaC02 of 40, Pa02 50, HC03$^-$ of 24. Pulse oximeter saturation values were in the low 90's. The patient had several episodes of clinical deterioration which included increased respiratory rate, decreased blood pressure, (59/39), reduced femoral and pedal pulses, dusky appearance of extremities and diffuse crackles by auscultation. During these episodes, radiographic findings were of increased pulmonary vascularity and persistent pulmonary edema. In an effort to maintain balanced circulation (pulmonary blood flow = systemic blood flow) the patient was placed on blended oxygen and nitrogen mixture of 18% to maintain Sa02's between 75% - 85%. Blood gas findings after initiation of this therapy were: pH 7.45, PaC02 44, Pa02 36, HC03$^-$ 22. Chest x-ray revealed a decrease in pulmonary vascular markings and a clearing of pulmonary edema. The patient did not demonstrate an increase in respiratory rate or work of breathing. Systemic perfusion was evaluated as improved by an increase in femoral and pedal pulses, improvement in temperature and color of extremities, B/P increased to 81/41, and urine output was normal. The patient was maintained on this therapy intermittently for 4 weeks at which time she was successfully transplanted. She was discharged home with no respiratory or neurologic complications. Conclusion: Short term therapy with hypoxic gas mixtures to lower Sa02 can be used to maintain balanced circulation and reduce pulmonary blood flow in patient's with hypoplastic left heart syndrome. Further evaluation of this therapy is necessary. The long term effects of hypoxic gas mixtures need to be studied before recommendations can be made to their role in the treatment of infants awaiting transplantation.

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[1] M K. Reeves-Hoche', et al, CPAP vs. BiPAP· Patient Compliance in the Treatment of Obstructive Sleep Apnea, Six Month Data in a Two-Year Study. Presented at ALA/ATS 1993. Study funded by Respironics [2] p = .09 [3] p ≤ .001

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HELIOX STATUS ASTHMATICUS: A CASE REPORT

Karl Wahl, R.R.T., Brenda Arians, R.R.T., David L. Gorenz, M.D., Clinical Assistant Professor of Medicine, University of Illinois College of Medicine
Saint Francis Medical Center
Peoria, Illinois

We report a case of intubated status asthmaticus with respiratory acidosis not responsive to conventional methods, but significantly improved with the use of Heliox. An 18 year old female known asthmatic presented to ER in obvious crisis with PCO2 148, Ph 6.88. After intubation and ventilation, respiratory acidosis persisted. The first 60 hours on heliox brought steady improvement in PCO2 and Ph to 48 and 7.39, respectively. An attempt to switch to O2-N2 mixtures resulted in PCO2 66, Ph 7.27. Upon restarting heliox; PCO2 52, Ph 7.38. Heliox was discontinued after 7 days. Resultant PCO2, Ph on FIO2 .3 were 41, 7.48 respectively. Extubated the next day, the patient was discharged 6 days after that. The mechanism of heliox centers around reduced kinematic viscosity. Peak and mean airway pressures were reduced with heliox. Use of heliox in these patients was first described in 1935, and the literature has since provided sporadic references. This case is a particularly clear illustration of the benefits of heliox in status asthmaticus.

OF-93-138

HYPOXIC AND HYPERCARBIC THERAPY IN HYPOPOLASTIC LEFT HEART POST-OP VENTILATION.

Hussein N. El-Lessy, RRT, Perinatal/Pediatric Specialist; Lawrence S. Fox, MD, Medical Director of Cardiovascular Surgery; Cook-Fort Worth Childrens Medical Center

A 3.5 kg patient was delivered by C-Section at 38 weeks gestation following an intrauterine diagnosis of hypoplastic left heart syndrome. He was intubated and started on prostaglandin E1 to maintain ductal patency. The patient's condition remained poor because of a restrictive interatrial communication that could not be enlarged by echocardiographically directed balloon septostomy. He then underwent an uneventful Stage I Norwood procedure. Immediately postoperatively, with 25% FiO2, systemic blood flow was satisfactory. However, as time passed and pulmonary vascular resistance fell, peripheral perfusion deteriorated and even with room air ventilation metabolic acid production ensued. Hypoxic and hypercarbic therapy was instituted as follows: Nitrogen, Carbon Dioxide and Oxygen were connected to a Sechrist triple flowmeter. The output low pressure tubing was connected to the low pressure gas inlet on the Siemans Servo 900C ventilator. Hypoxic ventilation to 17% FiO2 and PaCO2 in the range of 45-50 mmHg (InCO2 1-20 mmHg) was achieved. These measures were effective in increasing pulmonary vascular resistance in this parallel circulation physiology. Thus, by reducing pulmonary blood flow (PBF), we increased systemic blood flow. Patient discharged on post-op day 28. In conclusion, in this patient we were able to successfully maintain optimal minute ventilation while utilizing hypoxic and hypercarbic therapy to regulate PBF.

OF-93-147

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INFANTS WITH SEVERE LUNG AIRWAY OBSTRUCTION AND THEIR ACUTE RESPONSE TO HELIUM-OXYGEN MIXTURE (HeO_2)

—Augusto Sola, M.D., James G. Bisgaard, R.R.T., R.C.P., UCSF Medical Center, San Francisco, California

Introduction: Helium is an inert gas that does not react with biological membranes, has high kinematic viscosity, and has increased diffusion coefficient for CO_2. We describe the administration of HeO_2 to 7 ventilated neonates with severely obstructed airways after they had shown no improvement or worsening with "conventional" therapies (diuretics, bronchodilators, ventilator changes, and high-frequency ventilation). **Methods:** All infants were premature (24-30 wks; birthweight 837 ± 165 g), had been initially treated for severe RDS, and continued on IMV. At the time of HeO_2 therapy, infants were >12 d of age (mean 16 ± 3d), on high ventilator settings (PAW 11-17 cm H_2O; FiO_2 0.58-0.95), and with clinical signs of deterioration (increasing ventilator settings or high frequency ventilation for the previous 48 h). All infants had $PaCO_2$ >45 torr, high FiO_2/PaO_2, and abnormal CXRs with airway distension and areas of hyperexpansion; two infants had bilateral pulmonary interstitial emphysema. During HeO_2, settings were adjusted to keep $PaCO_2$ <47 torr and PaO_2 45-70. **Results:** In all 7 infants, indices of ventilation and oxygenation improved after 20 hours of HeO_2: PIP from 26 ± 1.6 to 21 ± 1.3 cm H_2O, PAW from 14.0 ± 1.9 to 9.7 ± 1.8 cm H_2O, Rate from 59 ± 11 to 45 ± 6, $PaCO_2$ from 51 ± 4.3 to 43 ± 4.8 torr and FiO_2/PaO_2 from 1.6 ± 0.4 to 0.9 ± 0.2. CXRs improved in all infants, with 5 infants showing a rapid (<8 h) and significant decrease in gas trapping. Duration of HeO_2 therapy was 28-60h (mean, 46h). Six infants were extubated 8 ± 2 days later and survived. **Conclusions:** In these preliminary observations, 7 infants with severe lower airway obstruction improved when HeO_2 replaced N_2-O_2. The lower density and increased laminar flow of helium compared to N_2 can be advantageous for neonates with respiratory compromise complicated by severe lower airway obstruction and gas trapping.

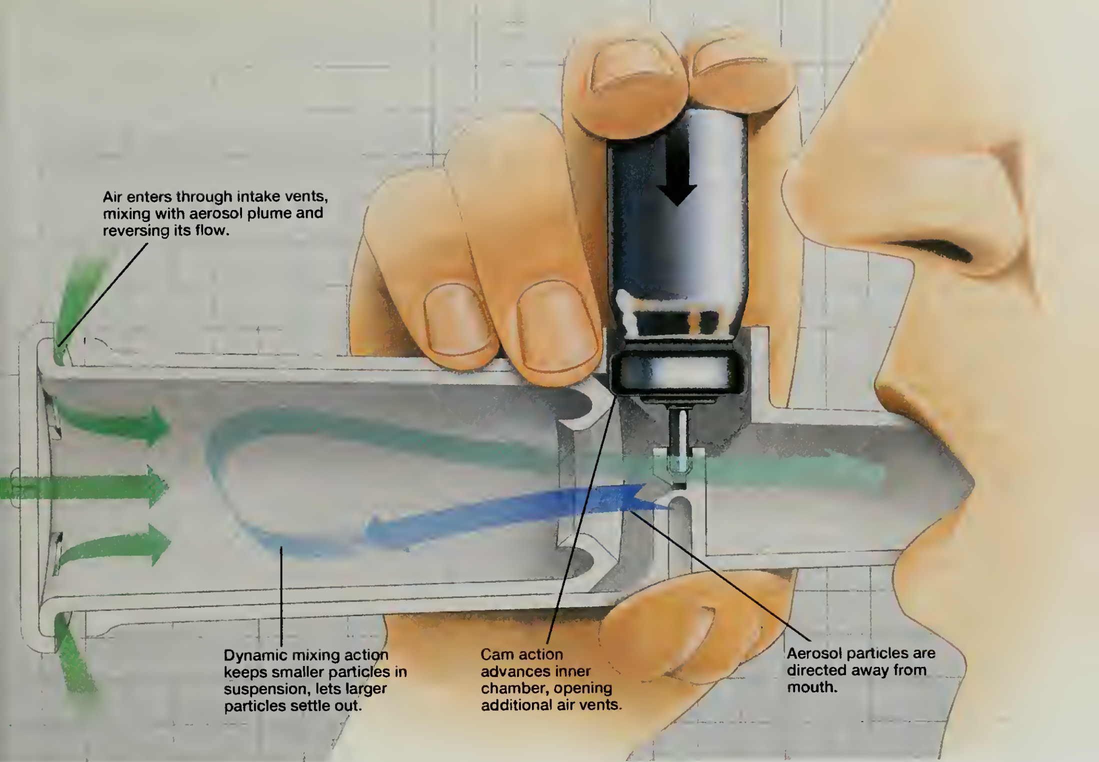
OF-93-196

HELIOX SIGNIFICANTLY AFFECTS PEAK PRESSSURE (PIP), TIDAL VOLUME (V_t) and FiO_2 DELIVERED BY INFANT VENTILATORS

—James G. Bisgaard, R.R.T., R.C.P., James B. Fink, M.S., R.C.P., Augusto Sola, M.D., UCSF Medical Center, San Francisco, California.

Introduction: On occasion Heliox (He 80%-O_2 20%) is provided as a gas source instead of compressed air (CA; N_2 79%-O_2 21%) for time cycled, pressure limited infant ventilators. Flow conversion factors for Heliox, available for use with analog thorpe tube type flowmeters, are not routinely used. We designed this study to evaluate the effects of replacing CA with Heliox on: 1.) PIP, 2.) Correlation of FiO_2 between blender and O_2 analyzer and, 3). V_t measurements and delivery. **Methods:** Two infant respirators (Infrasonics Infant Star; Bear Cub), NVM Monitor (Bear), Teledyne O_2 Analyzer, and a TTL Michigan Test Lung were used. Gas sources of ventilators were O_2 and CA as usual; Heliox replaced CA in the air inlet of the ventilator for different study periods. Data was collected delivering room air (N_2 79%-O_2 21%) or helium 79%-O_2 21% to the TTL. Baseline settings in room air were: Flow 12 lpm, PIP 23 cm H_2O, Ti 1 sec., rate 12x min. V_t was monitored by TL and NVM, PIP by infant ventilators and TTL. **Results:** In both ventilators with room air: PIP was 23 ± 2 cm H_2O and V_t 222 ± 2 ml. V_t by NVM monitor correlated precisely with TTL as did O_2 blender and analyzed FiO_2. When changed to Helium 79%-O_2 21%: PIP increased to 36.5 ± 1 cm H_2O, V_t to 344.5 ± 1 ml and V_t by NVM lost its accuracy and reliability. The O_2 blender needed to be set between 23-27% to deliver 21%. **Conclusions:** When using Heliox instead of CA in clinical practice the ventilator needs to be disconnected from the infant until all settings are readjusted and the same PIP and FiO_2 as with CA are being delivered. Furthermore, NVM monitoring of V_t cannot be utilized

OF-93-197



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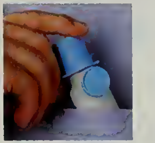

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HELIUM EFFECT ON VENTILATOR OUTPUT

William W. Quinn RPFT RRT Ochsner Foundation Hospital New Orleans, LA In view of recent case reports validating the clinical efficacy of helium for asthmatics on the ventilator even when used with FiO2s up to .40, I sought to document the effect of helium on common ventilators. Method: An 80/20 heliox mix was substituted for air in four types of ventilator: A Bear III, a Servo 900, a 7200, and an IRISA. An O2 analyzer determined actual O2 percent, and a Collins 6-liter spirometer was used to determine actual tidal volume (TV) delivered and inspiratory time at different FiO2s, the ventilator being set at a TV of 800 and rate of 12 throughout. Results: The 7200 and the IRISA became non-operational, due to inaccurate volume readings caused by the helium gas and no data were obtained. Otherwise (n=5):

Servo Ventilator			
Set FiO2	1.0	.40	.21
Actual FiO2	1.0	.34	.21
Actual TV (Liters)	.7	.84	.93
Actual I-time(sec)	1	1	1

Bear 3 Ventilator			
Set FiO2	1.0	.40	.21
Actual FiO2	1.0	.36	.21
Actual TV (Liters)	.7	.70	.72
Actual I-time(sec)	1	.7	.5

Conclusion: The 7200 and IRISA cannot be used with helium mixtures. The Servo and Bear 3 will operate with helium, but with increased flow rates, which in the case of the Servo results in higher tidal volumes as the I-time is held constant, and in the case of the Bear results in shorter I-times with the same tidal volume. The Bear, unfortunately, uses 9 helium H-cylinders per day to maintain a 10 L minute volume. The Servo can be set up with the low pressure inlet to use far less. The decision to use helium in the place of nitrogen in flow-dependent ventilators can be made only if the clinician is willing to assume responsibility for assuring that delivered tidal volumes and FiO2 are controlled.

OF-93-216

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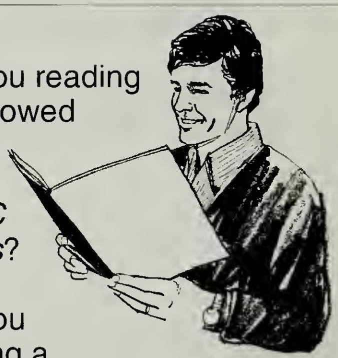

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PATIENT-VENTILATOR SYNCHRONY IN PROPORTIONAL ASSIST VENTILATION (PAV) AND PRESSURE SUPPORT VENTILATION (PSV)

-Jun Takezawa, MD; Toshio Fukuoka, MD, RRT; Naoto Kuwayama, MD; Toshiro Hotta, RRT; Yurii Konyukov, MD; Yasuhiro Shimada, MD. Nagoya University Hospital, Nagoya, Japan.

Patient-ventilator synchrony acomplished by PAV and PSV was compared using a one-compartment mathematical lung model. Methods: The mechanical property of our lung model consisted of chest wall compliance of 0.1 L/cmH$_2$O and varied combination of lung compliance (0.1 and 0.02 L/cmH$_2$O) and resistance (5 and 25 cmH$_2$O/L/sec). RR was 20 breath/min. Both PAV and PSV had the same flow triggering sensitivity and flow termination criteria of 3 L/min. The K$_1$ and K$_2$ of PAV was set at 0.5 according to the original description by Younes (ARRD 1992; 145:114-120). The pressure support level was adjusted to obtain the same V$_T$ attained during PAV. The identical Pmus was used in each model. The airway, alveolar and pleural pressure fluctuations were computed following Euler's method. Results: Shown in the table and figure.

Table

[Model 1: C=0.1, R=5, V$_T$=0.72L]

	Paw$_{max}$	Palv$_{max}$	PEEPi	Ppl$_{min}$	Ppl$_{max}$
PAV	6.7	6.2	0.8	-3.0	-0.4
PSV	6.0	5.9	0.8	-3.0	-0.4

[Model 2: C=0.1, R=25, V$_T$=0.75L]

	Paw$_{max}$	Palv$_{max}$	PEEPi	Ppl$_{min}$	Ppl$_{max}$
PAV	15.4	14.8	14.2	-22.1	2.0
PSV	11.0	15.4	14.7	-22.0	2.2

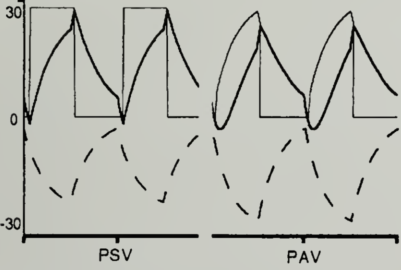
[Model 3: C=0.02, R=5, V$_T$=0.76L]

	Paw$_{max}$	Palv$_{max}$	PEEPi	Ppl$_{min}$	Ppl$_{max}$
PAV	23.3	23.5	0.4	-18.0	-2.6
PSV	19.0	19.1	0.4	-14.3	-2.2

[Model 4: C=0.02, R=25, V$_T$=0.76L]

	Paw$_{max}$	Palv$_{max}$	PEEPi	Ppl$_{min}$	Ppl$_{max}$
PAV	27.3	23.4	5.7	-27.3	-3.3
PSV	28.0	27.4	5.1	-22.0	-2.7

Figure(Model 4)



The fine, bold and dashed lines indicate Paw, Palv and Ppl, respectively.

Conclusion: Peak Paw was higher during PAV than that during PSV at a matched V$_T$ in all the experimental settings. The Ppl fluctuation was bigger in PAV compared with that in PSV in the low C lung model, suggesting that WOB was more efficiently reduced by PSV in the low C lung.

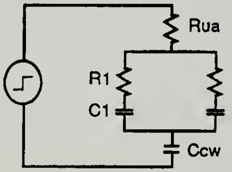
OF-93-016

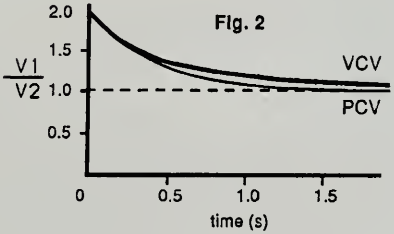
Pressure Controlled Ventilation Is Superior to Volume Controlled Ventilation in a Model of Obstructive Lung Disease

Mohamad F. El-Khatib, MS, Robert L. Chatburn, RRT, Rainbow Babies & Childrens Hospital and Case Western Reserve University, Cleveland, OH.

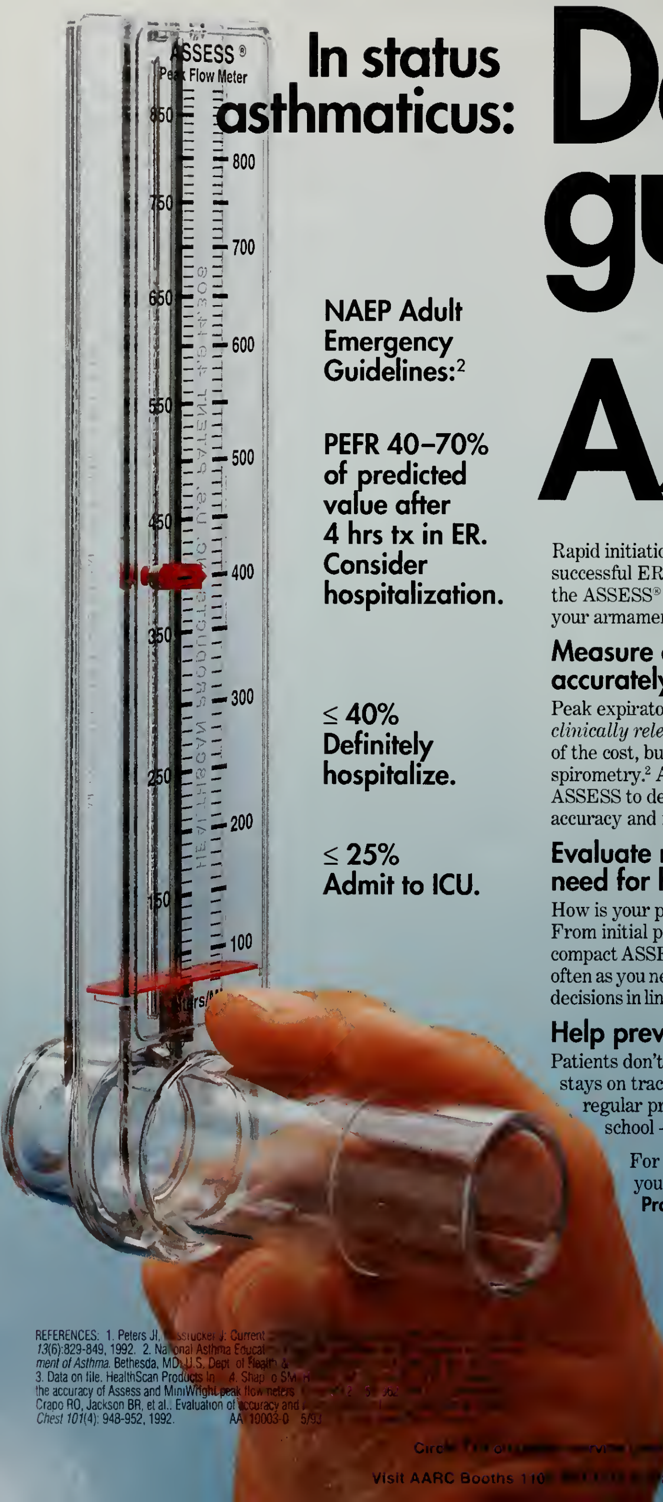
Introduction: The purpose of this study was to describe the relative merits of pressure controlled ventilation (PCV) versus volume controlled ventilation (VCV) in terms of distribution of ventilation and potential risk of pulmonary volutrauma. **Methods:** We used a mathematical model consisting of two parallel lung units (Fig. 1), each composed of a resistance (R) connected in series with a compliance (C). The time constants of the two units were made unequal to simulate nonhomogeneous obstructive lung disease (ie, C1 = C2, R1 ≠ R2). The model included upper airways resistance (Rua) and chest wall compliance (Ccw). We used the LaPlace transform to solve the model for volume change of each unit as a function of time in response to either constant pressure input (ie, PCV) or constant flow input (ie, VCV). **Results:** Fig. 2 illustrates the ratio of volumes into the two lung units. At the start of inspiration the ratio is equal to R2/R1. This ratio tends towards a steady state value of C1/C2 (=1). **Conclusion:** Ratio values ≠ 1 indicate unequal distribution of ventilation. Thus, PCV results in more even distribution of ventilation than VCV for all inspiratory times. Furthermore, if PCV is matched to the same tidal volume as VCV, the risk of overdistention of the more resistant lung unit may be greater with VCV in this model. For both modes, however, distribution of ventilation becomes more even as inspiratory time increases. This suggests the use of low frequencies.

Fig. 1





OF-93-028



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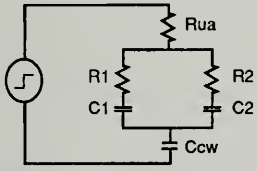
VOLUME CONTROLLED VENTILATION IS SUPERIOR TO PRESSURE CONTROLLED VENTILATION IN A MODEL OF RESTRICTIVE LUNG DISEASE Robert L. Chatburn, RRT, Mohamad F. El-Khatib, MS, Rainbow Babies & Childrens Hospital and Case Western Reserve University, Cleveland, OH.

INTRODUCTION: The purpose of this study was to describe the relative merits of pressure controlled ventilation (PCV) versus volume controlled ventilation (VCV) in terms of distribution of ventilation and potential risk of pulmonary volutrauma. METHODS: We used a mathematical model consisting of two parallel lung units (Fig. 1), each composed of a resistance (R) connected in series with a compliance (C). The time constants of the two units were made unequal to simulate nonhomogeneous restrictive lung disease (ie, $C1 \neq C2$, $R1 = R2$). The model included upper airways resistance (Rua) and chest wall compliance (Ccw). We used the LaPlace transform to solve the model for volume change of each unit as a function of time in response to either constant pressure input (ie, PCV) or constant flow input (ie, VCV). RESULTS: Fig. 2 illustrates the ratio of volumes into the two lung units. At the start of inspiration the ratio is equal to R2/R1 (=1). This ratio tends towards a steady state value of C1/C2. CONCLUSION: Ratio values $\neq 1$ indicate unequal distribution of ventilation. Thus, VCV results in more even distribution of ventilation than PCV for all inspiratory times. Furthermore, if PCV is matched to the same tidal volume as VCV, the risk of overdistention of the more compliant lung unit may be greater with PCV in this model. For both modes, however, distribution of ventilation becomes more uneven as inspiratory time increases. This suggests the use of high frequencies.

Fig. 1



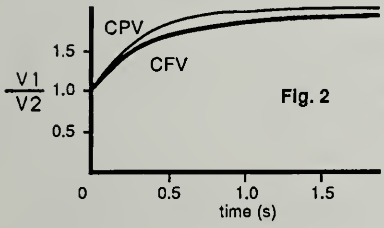


Fig. 2

OF-93-029

ASSESSING PEEP APPLIED TO ADDRESS VENTILATOR DYSSYNCHRONY IMPOSED BY INTRINSIC PEEP FROM AIRFLOW OBSTRUCTION. Robert R. McConnell, Jr., RRT and Neil R. MacIntyre, M.D. Duke University Medical Center. A 73 year old female with COPD was intubated and placed on a ventilator due to respiratory failure. The patient was placed in the pressure assist control mode and was noted to have inspiratory effort that did not trigger the ventilator. Airway pressure and flow, and esophageal pressure tracings demonstrated 18cmH20 intrinsic PEEP as the cause of the triggering difficulty, that is, there was an 18 cmH20 esophogeal pressure change (Pes) without corresponding airway pressure changes or assisted breaths. Applied PEEP of 4,9, and 13 cmH20 was given in an effort to equilibrate intrinsic PEEP throughout the ventilator circuit, thereby reducing this inspiratory triggering threshold load. Care was taken to avoid excessive PEEP which would cause an increase in FRC. This was monitored by assessment of Pes changes neccessary to trigger, by the exhaled volume (ie. decreases in this suggest an increase in FRC in pressure limited ventilation) and assessment of induced trapped gas (ie. volume returned after release of applied PEEP). We found that applied PEEP up to 13 cmH20 decreased the effort without a decrease in exhaled volume or increase in trapped gas. This suggested that 13 cmH20 applied PEEP was beneficial in reducing triggering work without an increase in FRC. This case illustrates how patients with airflow obstruction who are mechanically ventilated may have significant levels of work imposed or be unable to cycle the ventilator due to intrinsic PEEP. Careful application of PEEP, by monitoring respiratory mechanics under these circumstances, appears beneficial.

APPLIED PEEP	TIDAL VOLUME	Pes TRIGGER
0	340cc	-18cmH20
4	340cc	-15cmH20
9	400cc	-10cmH20
13	430cc	-5cmH20

OF-93-047

A COMPARISON OF FLOW AND PRESSURE TRIGGERING SYSTEMS DURING CPAP. RD Branson, RRT, K Davis Jr, MD, DJ Johnson, MD, RS Campbell, RRT. University of Cincinnati Medical Center, Cincinnati, OH.

The work to trigger the ventilator can effect the patients total WOB. Using a two-chambered lung model driven by a ventilator set at 10 b/min, decelerating flow pattern and inspiratory flows of 30 60, and 90 L/min, we measured the WOB_I in 4 ventilators at 0 and 10 cmH_2O CPAP. Using a calibrated pneumotachograph and pressure tap at the proximal airway, WOB was measured in J/L as the area subtended by the pressure volume curve. Electronic integration was accomplished using a VenTrak monitor. Peak negative pressure (PNP) during inspiration as well as end inspiratory pressure (EIP) were also recorded from P/V curves. All ventilators (Siemens 300, Hamilton Veolar, P-B 7200ae, Bird 8400STi) were set up according to manufacturer's recommendations using the most sensitive flow and pressure triggering settings. Results at a flow of 60 L/min are shown below (mean) in J/L.

	PT (0 CPAP)	FT	PT (10 CPAP)	FT
300	0.016	0.007	0.012	0.019
7200ae	0.062	0.017	0.068	0.021
Veolar	0.032	0.021	0.034	0.029
8400STi	0.071	0.079	0.039	0.046

Flow triggering systems are associated with a lower WOB_I during CPAP than pressure triggering systems. Unlike previous studies, we did not find a difference in WOB_I between 0 and 10 cm H_2O CPAP. We did observe that the lowest WOB_I was associated with the lowest PNP and highest EIP. At a 0 CPAP setting the ventilators delivered 1.0 to 4.1 cm H_2O of pressure support as a means of reducing WOB_I. The WOB_I with the current generation of ventilators is comparable despite significant differences in the actual value for WOB_I. These differences, however, represent such a small portion of the total WOB that they are probably of little clinical significance.

OF-93-107

PATIENT-VENTILATOR FLOW SYNCHRONY AS A FUNCTION OF VENTILATORY SUPPORT MODE. Robert McConnell,BA,RRT, Dennis Yetsko,BS,RRT, Aneysa Sane,MD, Neil MacIntyre,MD.Duke University Medical Center, Durham N. C. During assisted mechanical ventilation, delivered machine flows should be in accordance with patient demand. If this in not the case, significant imposed work may be performed by the patient and patient ventilator flow dys-synchrony is said to exist. Variable flow (pressure limited) mechanical breaths would be expected to synchronize with patient flow demands better than fixed flow (volume cycled) mechanical breaths. Unfortunately, conventional variable flow (pressure limited breaths), by their very design do not provide a guaranteed volume with each breath. We describe below a case that illustrates patient-ventilator flow dys-synchrony with fixed flow-volume cycled breaths which is improved by addition of variable flows and pressure limiting features to the underlying volume cycled breath. The patient was a 51 year old female with viral pneumonia and respiratory failure receiving volume cycled assist-control ventilation (Vt 650cc, RR 36, Flow 90 lpm decelerating). Patient-ventilatory flow synchrony was assessed in two ways. First, airway tracings over time were obtained during both the assisted (patient active) and the controlled (patient passive) breath and a pressure time product (PTP) was calculated using a digitizer. The difference between the assisted and controlled PTP reflected the airway pressure dys-synchrony (Paw:PTP). Second, esophageal pressure (Pes) tracings over time were obtained and a PTP referenced to baseline pressure was calculated during the assisted breath (Pes:PTP). Measurements were done during the baseline settings, during a change to square wave flow, and during a change to 60 lpm decelerating pattern. In addition, this basic volume cycled breath was modified to provide a variable flow with pressure limiting of 45 cmH20. (Pressure augmentation-Bear 1000, Bear Medical Systems, Riverside, Calif.) Results:

Flow Pattern	Paw:PTP (cmH20•sec)	Pes:PTP (cmH20•sec)
90 lpm-dec	5.82	7.17
90 lpm-square	6.03	10.1
60 lpm-dec	8.69	9.4
Pres Aug 45 cmH20	1.52	6.6

This case illustrates that a variable flow-pressure limited assisted breath that could be volume cycled reduced patient-ventilator flow dys-synchrony while maintaining a volume guarantee.

OF-93-114

ATTENUATION OF INCREASED METABOLICS AND CARDIOPULMONARY DEMAND DURING STRESS USING PROPOFOL.

M Kemper, BA, CRTT, D Cohen MD, C Weissman, MD, Columbia Presbyterian Medical Center, Departments of Medicine and Anesthesiology, New York, NY

Introduction: Adult ICU patients require many therapeutic interventions (TI). The TI with the highest increase in metabolic and cardiopulmonary demand in the ICU is chest physical therapy (CPT). This study tested the ability of the short-acting anesthetic agent Propofol to attenuate stressful increases during TI. CPT was used as a model for TI induced stress.

Methods: With IRB approval, 16 postoperative, ventilator dependent, general surgical patients were studied. All were monitored with peripheral and pulmonary artery catheters. They were ventilated in the SIMV mode with the PB 7200 and metabolically monitored with a calibrated and validated Sensormedics Deltatrac. Two successive sessions of CPT were performed. Randomly 0.75 mg/kg of propofol or placebo were given IV bolus two minutes before CPT. Each session of CPT was preceded and followed by rest.

Results: Values are mean ± SD

		Rest	CPT	Rest
VO_2	PRO	233 ± 40	277 ± 105*	225 ± 33
(ml/min)	PLA	232 ± 50	394 ± 104*+	232 ± 40
DO_2	PRO	1145 ± 313	1133 ± 466	1063 ± 319
(ml/min)	PLA	1123 ± 368	1521 ± 576*+	1118 ± 307
ER	PRO	0.22 ± 0.06	0.26 ± 0.07*	0.23 ± 0.06
	PLA	0.22 ± 0.06	0.27 ± 0.06*	0.22 ± 0.05
SBP	PRO	124 ± 21	119 ± 30	119 ± 18
(mmHg)	PLA	126 ± 23	147 ± 25*+	125 ± 21
HR	PRO	92 ± 10	94 ± 13	89 ± 12
(min-1)	PLA	89 ± 13	104 ± 14*+	92 ± 10
VCO_2	PRO	185 ± 36	202 ± 51*	183 ± 29
(ml/min)	PLA	186 ± 34	276 ± 72*+	186 ± 34
V_E	PRO	7.6 ± 1.5	8.6 ± 1.7*	7.7 ± 1.5
(l/min)	PLA	7.9 ± 1.8	11.2 ± 2.5*+	7.7 ± 1.9
$PaCO_2$	PRO	36.5 ± 4.4	38.5 ± 4.0*	36.0 ± 3.8
(mmHg)	PLA	36.3 ± 3.9	39.9 ± 5.8*	36.8 ± 5.6
f	PRO	10.6 ± 3.3	14.5 ± 9.4	11.7 ± 4.4
(min-1)	PLA	11.8 ± 7.3	18.6 ± 6.8*	11.2 ± 3.9
V_A	PRO	4.4 ± 0.9	4.5 ± 0.9	4.4 ± 0.7
(l/min)	6	4.5 ± 0.9	6.0 ± 1.2*+	4.4 ± 0.9

*different than Rest ($p<0.05$)

+ difference from Rest significantly different when drug and placebo compared ($p<0.05$). ER - Extraction Ratio; DO_2 - Oxygen Delivery; VA-Alveolar Ventilation; VCO_2 - CO_2 Elimination

Discussion: Propofol eliminated significant increases in oxygen consumption and carbon dioxide production during CPT. Because of a lack of increased metabolic demand, hemodynamics and ventilation were not elevated during CPT. SBP actually decreased during CPT and remained at the lower value post CPT. While the SBP decrease was not statistically significant, in some cases it was clinically significant.

Conclusion: Propofol 0.75 mg/kg effectively eliminates the metabolic and hemodynamic response to CPT but, in some cases, can cause clinically worrisome decreases in the SBP.

1. Kemper M et al.: Resp. Care 37: 1313, 1992

OF-93-126

THE EFFECTS OF ADDING PRESSURE SUPPORT DURING CHEST PHYSICAL THERAPY ON VENTILATOR DEPENDENT PATIENTS

M Kemper, BA, CRTT, J. Harding, MD, C Weissman, MD, Columbia Presbyterian Medical Center, Departments of Medicine and Anesthesiology, New York, NY

Chest physical therapy (CPT) is routinely performed on postoperative, ventilator dependent patients (pts.) It increases oxygen consumption (VO_2) and minute ventilation (V_E). Ventilator dependent pts often cannot meet the increased ventilatory demands during CPT, causing an increase in $PaCO_2$. In an effort to attenuate this untoward effect of CPT, we increased ventilation by adding pressure support (PS) to increase the efficiency of spontaneously inspiratory efforts. A previous study showed that increasing the rate of IMV ventilation decreased O2 delivery. We hypothesized that the addition of PS would be more physiologic and therefore not decrease O2 delivery Methods: fifteen postoperative, ventilator dependent pts (spontaneously breathing during IMV) receiving CPT were studied. A Sensormedic Deltatrac (Yorba Linda, CA) was used to determine VO_2. Arterial and mixed venous blood were sampled from pulmonary and radial artery catheters. CPT was performed twice, once with 15cm H_2O PS and once without PS. Pts rested before and after each session. Calculations: Oxygen Delivery (DO_2)=VO_2/ER (ER - extraction ratio), Pulmonary Capillary Wedge Pressure (PCWP).

Results:

		REST	CPT	REST
VO_2	PS	241 ± 53+	381 ± 117	241 ± 51
(ml/min)	Baseline	246 ± 44+	409 ± 122	238 ± 59
$PaCO_2$	PS	37.7 ± 4.7	37.5 ± 62*	38.0 ± 4.6
(torr)	Baseline	38.2 ± 4.7+	41.0 ± 5.9	38.1 ± 4.7
SBP	PS	121 ± 16+	154 ± 24*	115 ± 16
(torr)	Baseline	116 ± 17+	164 ± 32	118 ± 15
PCWP	PS	9.2 ± 3.3+	11.3 ± 3.7*	8.9 ± 4.0
(torr)	Baseline	9.7 ± 3.2	15.0 ± 5.4	9.4 ± 3.4
RR	PS	11.1 ± 2.8+	20.8 ± 6.5*	11.2 ± 3.1
(min^{-1})	Baseline	10.5 ± 2.2+	25.8 ± 7.0	11.0 ± 2.9
DO_2	PS	1064±414+	1380±699	1114±392
(ml/min)	Baseline	1120±439+	1462±618	1046±428

Values are mean ± SD PSI= Pressure Support

*Significantly different than baseline values (P0.01).

+Significantly different than CPT values ($P<0.01$).

Discussion: PS 15 cm H_2O attenuated the increases in $PaCO_2$, SBP, PCWP and RR caused by CPT. There was little effect on oxygen delivery . PS 15 cm H_2O did not attenuate the VO_2 increase during CPT.

Conclusion: PS 15 cm H_2O may be beneficial in attenuating the hemodynamic and ventilatory stresses of CPT without O_2 delivery compromise. Further studies of PS>15 cm H_2O should be undertaken to determine if further attenuation can occur.

1. Kemper M et al.: Resp. Care 37: 1313, 1992
2. Weissman C., Kemper M., et al: Chest 86: 815-818, 1984

OF-93-127

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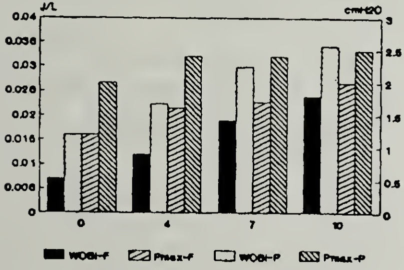
INFLUENCE OF INSPIRATORY RISE TIME (IRT%) ON THE IMPOSED WORK OF BREATHING (WOB$_I$)

Robert S. Campbell RRT*, Richard D. Branson RRT$^+$, James M. Hurst MD*, Ken Davis Jr. MD$^+$, Departments of Surgery, University of South Florida*, Tampa, Florida, University of Cincinnati$^+$, Cincinnati, Ohio.

Introduction: The IRT% setting adjusts the inspiratory flow delivered from the ventilator. The minimum IRT% (0) correspondes to the fastest initial flowrate. The cardiopulmonary effects of altering IRT% during PSV$_{max}$ has been previously reported (Resp. Care 90;35:1056). We studied the effects of IRT% on the WOB$_I$ using the Siemens 300 ventilator. **Method:** A two-chamber lung model was powered with a PB 7200ae ventilator set to deliver a Vt of 500 mL using a decelerating inspiratory flow pattern at peak flow of 30, 60, and 90 L/min.. A 7.0mm ET tube was used to connect the 300 ventilator to the test lung (TL) and TL compliance was set at 50 m^L/cmH$_2$O. CPAP and PSV levels of 0 and 10 cmH$_2$O were used randomly in all combinations (0,0;0,10;10,0;10,10) and pressure (-1) and flow (0) sensitivity were alternately set. The IRT% was set at 0, 4, 7 and 10% for each test condition. WOB$_I$ and maximum inspiratory subbaseline pressure (P$_{max}$) were measured using the Ven-TraK monitor. **Results:** Fig. 1 shows the WOB$_I$ and P$_{max}$ at settings of 0 CPAP, 0 PSV and 60 L/min using pressure and flow triggering at the various IRT% used. The minimum WOB$_I$ (0.0004) was measured at 10 PSV, 0 CPAP, 30 L/min using flow triggering at 0% IRT. The maximum WOB$_I$ (0.069) was seen at 0 PSV, 10 CPAP, 90 L/min using pressure triggering at 10% IRT. The effect of IRT% on the WOB$_I$ and P$_{max}$ was similar at all test conditions.

Fig. 1



Conclusions: WOB$_I$ is minimal using the fastest flow setting (0% IRT). WOB$_I$ increases as flow is decreased. WOB$_I$ is lower during flow triggering than with pressure triggering. The addition of 10 cmH$_2$O CPAP increases the WOB$_I$. The addition of 10 cmH$_2$O PSV decreases WOB$_I$. Clinical investigation of the effects of IRT% on the WOB$_I$ is warranted.

OF-93-143

COMPARISON OF EXHALATION VALVE SENSITIVITY ON DISPOSABLE BREATHING CIRCUITS

Paula Kolar BSME, ECRI, Plymouth Mtg, PA.

Introduction: The exhalation valve on a portable ventilator breathing circuit (BC) must close in response to spontaneous breathing efforts for the patient to initiate a breath in an assist mode or to synchronize breaths during SIMV. We determined the minimum inspiratory flow required to draw the exhalation valve closed on six models of disposable BCs. **Method:** We connected the BC between one side of a two-chambered test lung and a portable ventilator that operated in the assist/control mode with its sensitivity control adjusted to -1 cm H$_2$0. A ventilator with a rectangular inspiratory flow waveform drove the other side of the test lung, which was mechanically linked to our simulated spontaneously-breathing patient. We simulated spontaneous breaths at an inspiratory flow of 5 L/min and increased the flow by 5 L/min until the ventilator detected a breathing effort and responded with a machine breath when the tidal volume of the spontaneous breath was less than 100 mL. We tested at least five BCs from each manufacturer with an empty humidifier chamber in the BC and with the exhalation valve orientated in its least sensitive position. **Results:** The chart below lists the minimum inspiratory flow in L/min required to trigger a ventilator with a sensitivity control setting of -1 cm H$_2$0 when less than a 100 mL spontaneous breath is taken.

Model	Inspiratory Flow (L/min) of six BCs					
Aeq 6161 *	5	5	5	5	5	5
B&F 64673	10	5	25	10	45	**
Bxtr 1797	5	5	5	5	5	5
BMD 3030 #	10	30	25	25	25	**
IPI 6427	5	5	5	5	5	5
PMP 6400 #	30	30	25	30	25	25

* BC is no longer available.

** Sixth BC was not tested.

# Manufacturer is planning on modifying its exhalation valve.

Aeq=Aequitron, Bxtr=Baxter, BMD=Bio-Med Devices, PMP=Professional Med Products

Conclusions: A patient who generates weak spontaneous breaths (e.g., patients with neuromuscular disease) may not be able to trigger a ventilator with a -1 cm H$_2$0 sensitivity setting with the B&F, BMD, and PMP BCs. It may be possible to use these BCs if the ventilator's sensitivity control setting can be lowered. The B&F BC had the most variability in exhalation valve sensitivity. Variations between individual BC's exhalation valve sensitivity can be a problem when the BC is changed because failure to trigger the ventilator could mistakenly be interpreted as a deterioration of the patient's condition.

OF-93-182

FLOWBY DOES NOT CLINICALLY DECREASE THE WORK OF BREATHING AND PRESSURE TIME PRODUCT IN COPD PATIENTS-

Kelly Jager RRT, Tammy Holland RRT, Martin Tweeddale MD. Vancouver General Hospital, Vancouver, BC Canada

The addition of flowby to CPAP has been shown to decrease the inspiratory work and the work required to trigger a spontaneous breath on the 7200a ventilator. In 10 patients with COPD, we compared the work of breathing (WOB) and pressure time product (PTP) on CPAP alone, with the WOB and PTP on CPAP plus flowby. Patients were entered into the study if they were ventilated with a 7200a ventilator and judged clinically to be ready for weaning. All patients had an esophageal balloon inserted and WOB and PTP were calculated using a CP 100 pulmonary monitor. Control values were obtained on either pressure support or assist control and adjusted to ensure a WOB < 0.3 J/L. Patients were then randomly assigned to either 20 minutes of flowby plus CPAP or 20 minutes of CPAP alone in alternating order. Between each test mode, patients were rested for 20 minutes on pressure support or assist control, ensuring that the WOB was < 0.3 J/L. The flowby was set with a base flow of 20 L/min and a sensitivity of 3.0 L/min. CPAP levels were kept constant in all modes and set between 5.0 and 10.0 cm H_2O. In the last five minutes of each mode, a 40 breath printout was obtained from the pulmonary monitor and an average WOB and PTP were obtained for each patient. The mean values for all patients were compared by paired t-test. The WOB on CPAP alone was 1.19 ± 0.4 J/L and for flowby plus CPAP 1.11 ± 0.38 J/L ($p=.05$). The PTP on CPAP alone was 247 ± 99.5 $cmH_2O \cdot sec/min$ and on CPAP plus flowby 235 ± 104 cm $H_2O \cdot sec/min$ ($p>.1$). In this group of COPD patients a clinically significant difference was not found between the WOB or PTP when CPAP alone was compared with CPAP plus flowby. Our results may differ from others due to methodology and/or patient sample. Further studies should be done to define the patient population in whom flowby may be beneficial.

OF-93-210

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THE EFFECT OF VENTILATOR TYPE ON OXYGEN CONSUMPTION AND WORK OF BREATHING DURING PRESSURE SUPPORT VENTILATION OF INFANTS

Mohamad F. El-Khatib, MS, Robert L. Chatburn, RRT, David L. Potts, RRT, Paul G. Smith, DO, Jeffrey L. Blumer, PhD, MD, Rainbow Babies & Childrens Hospital and Case Western Reserve University, Cleveland, OH.

INTRODUCTION: We wished to investigate whether oxygen consumption ($\dot{V}O2$) and patient work of breathing needed to trigger inspiration (WOB) are affected by the type of ventilator delivering pressure support ventilation (PSV) for infants in PICU. **METHODS:** Eight PICU patients (age: 2-23 months, weight: 4-14 kg) were studied on their prescribed level of PSV. While maintaining a constant PSV level, patients were switched from the Siemens Servo 900C, the Bird V.I.P., and the Newport Wave E200 in a random order. At steady state, $\dot{V}O2$ was measured with a metabolic cart (Cybermedic) and WOB was measured with a pulmonary monitoring system (Ventrak). Patient distress levels were assessed using a behavioral scoring system. Mean values (20 breaths/patient) for $\dot{V}O2$ and WOB were compared with ANOVA and Sheffé tests with $p < 0.05$ taken as significant. **RESULTS:** The distress level of the patients did not change as a result of changing ventilators. Figures 1 & 2 indicate that the lowest $\dot{V}O2$ and WOB were achieved with the Bird V.I.P. **CONCLUSION:** Statistically significant and clinically important differences in $\dot{V}O2$ and WOB were observed among ventilator models. We conclude that $\dot{V}O2$ and WOB in critically ill patients may be reduced using the latest generation of mechanical ventilator optimized for infant and pediatric use. We speculate that appropriate selection of ventilator type will improve patient comfort and facilitate weaning from ventilator support.

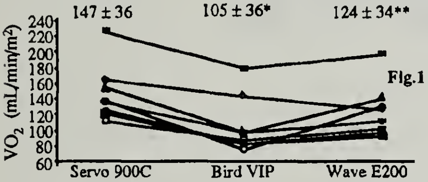

Fig.1

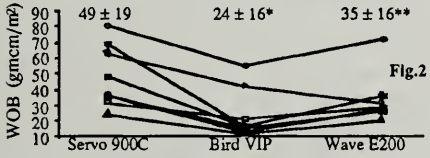

Fig.2

* $p < 0.05$ compared to other ventilators (ANOVA)

** $p < 0.05$ compared to the Servo 900C (Scheffé test)

OF-93-030

RELATIVE HUMIDITY DELIVERED BY A NEONATAL HEATED WIRE CIRCUIT.

Lynn Sullivan, RRT, Kevin Strong, RRT, Judy Trahey, RRT, Dean Heas, MEd, RRT. Massachusetts General Hospital, Boston, MA.

Clinical problems related to inadequate humidity with a heated wire circuit have recently been described. Miyao et al (Crit Care Med 1992;20:674) suggested that relative humidity (RH), *not* absolute humidity, is important when using a humidifier with a heated wire circuit. Whereas absolute humidity determines the total amount of H_2O deprived of the respiratory tract, RH determines from where the H_2O is deprived. At a low RH, H_2O is deprived of the upper respiratory tract and trachea. This could result in drying of secretions in artificial airways and large central airways. We conducted this study to evaluate relative humidity (RH) with a neonatal heated wire circuit. METHODS: We used 3 Hudson RCI Conchatherm III Plus humidifiers with Baxter Isothermal Custom circuits. An Air-Shields Isolette warmed the distal ventilator tubing and patient Y-piece to simulate lower respiratory tract temperature of 36±0.6°C. The circuit temperature probe was outside the Isolette for all evaluations. RH measurements were made with at least 15 min equilibration after each change in settings using a Fisher Scientific hygrometer with calibration traceable to NIST. Concha humidity settings of minimum (min), mid-range (mid), and maximum (max) were evaluated. At temperature settings of 35°, 36°, and 37°, the following ventilator settings were used: pressure 25/5 cm H_2O, rate 20/min, flow 8 L/min, Ti 0.75 s; pressure 40/10 cm H_2O, rate 40/min, flow 12 L/min, Ti 0.75 s. At a temperature of 32°, 33°, and 34°, the following settings were used: flow 5 L/min, CPAP mode; ventilator off, expiratory line disconnected, inspiratory line delivering gas to a hood inside the Isolette. Humidifiers and circuits were used per manufacturers' specifications. RESULTS: Median RH for the temperature and humidity settings (n=6) were:

temperature setting	humidifier setting		
	min	mid	max
32°	65.3%	75.6%	83.5%
33°	66.8%	77.6%	86.6%
34°	76.4%	80.8%	88.8%
35°	66.2%	84.3%	100%
36°	77.2%	93.8%	100%
37°	85.5%	99.2%	100%

There was a significant difference in RH between temperature and humidity settings ($P < 0.001$ by Kruskall-Wallis ANOVA in both cases). CONCLUSIONS: Although further work is needed to determine the clinical importance of our results, our data shows that RH can be low with the heated wire circuits that we evaluated.

OF-93-063

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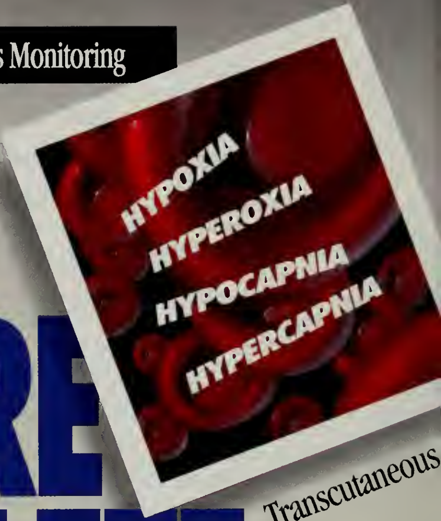

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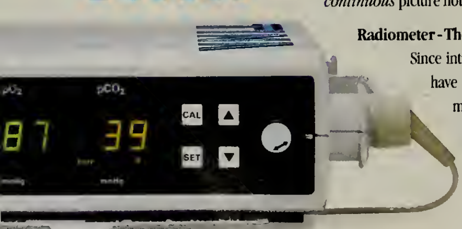

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PRELIMINARY EXPERIENCE WITH FLOW SYNCHRONIZED VENTILATION IN CONGENITAL DIAPHRAGMATIC HERNIA PATIENTS FOLLOWING ECMO-

Peter Betit RRT, Daphne Munhall RRT,
Jay Wilson MD, Children's Hospital,
Boston, Massachusetts

Introduction: In our institution the mean post-ECMO ventilator duration in 54 surviving congenital diaphragmatic hernia (CDH) patients was 44 days. This prolonged ventilator course has been attributed to difficulties with fluid and nutrition management, narcotic withdrawal and pulmonary hypoplasia associated with this disease. The Bird VIP flow synchronization ventilator (FSV) incorporates a proximal airway pneumotachometer which allows flow triggered support. This device was evaluated in 5 CDH patients who required ECMO. **Methods:** Muscle relaxants were reversed and sedatives weaned to permit spontaneous respiratory effort while maintaining analgesia. The time cycled, assist control mode was selected with a flow trigger threshold of 0.2-0.6 L/min. All breaths were augmented by an initial PIP of 26-31 cmH_2O. Flow cycled breaths were achieved by adjusting the termination sensitivity at 5-20% of the initial peak flow rate, allowing autoregulation of inspiratory time from 0.2-0.6 secs. **Results:** In 3 patients, clinically acceptable ABGs were achieved and respiratory rate was 60+/-20. PIP was weaned in increments of 1-2 cmH_2O while maintaining Vt of 5-8 ml/kg. Extubation occurred when PIP was reduced to 15 cmH_2O. The average days to extubation were 12+/-2.5. Due to medical complications, 2 patients required reinstitution of muscle relaxants and did not survive. There were no complications associated with this mode of ventilation. **Discussion:** Our preliminary experience suggests that flow triggered, pressure limited, flow cycled ventilation may be a potentially beneficial mode in expediting the weaning process in certain cases. It may facilitate the reversal of muscle relaxants and the weaning of narcotics in the immediate post-ECMO period. Further investigations are warranted.

OF-93-070

A COMPARISON OF CONTINUOUS FLOW (CF) AND DEMAND FLOW (DF) DELIVERY SYSTEMS DURING IMV ON OXYGEN CONSUMPTION IN NEONATES.

Theresa Wahlig, MD; Keith Holloman, BA,RRT; Stephen J. Boros, MD; Mark C. Mammel, MD; Dennis Bing, RRT. Children's Hospital of St. Paul, St. Paul, MN.

Initiation of inspiratory gas delivery during IMV by patient effort should improve synchrony between patient and ventilator. We hypothesized that this decrease in respiratory work would be reflected by decreased oxygen consumption (VO_2) and carbon dioxide production (VCO_2). To test this hypothesis, we measured VO_2 and VCO_2 during IMV, and compared a demand flow system which features a preset continuous background of 4 L/m to a conventional continuous flow mode (both using the Infant Star ventilator, Infrasonics, Inc.). We studied two groups of patients using a cross-over design. Group I consisted of infants being weaned from mechanical ventilation. Weight range was 990-3320 grams with a mean of 1880 ± 865 grams. Ventilatory support index (VSI), calculated as FiO2 x IMV rate, ranged from 2.84-3.78 with a mean of 2.84 ± 0.71. All patients in this group started on CV, then crossed over to DF. Group II consisted of infants ventilated during the acute stages of respiratory failure. Weight range was 850-3060 grams, mean = 2090 ± 973 grams. VSI ranged from 5.25-28.6, with a mean of 12.9 ± 9.06. Patients in this group were randomly assigned to CF or DF, then crossed to the alternative therapy. VO_2 and VCO_2 were measured using an open-circuit indirect calorimeter validated for neonatal use (MGM jr Metabolic cart, Life Energy Systems, Inc.) for a duration of a least 20 minutes. Data were analyzed using paired 2-tailed Student t-tests.

Group I - Weaning from IMV

	CF	DF
VO_2	6.98 ± 0.28	6.76 ± 1.5
VCO_2	6.98 ± 0.96	6.62 ± 1.12
V_e	289 ± 50	279 ± 69

Group II - Acute Respiratory Failure

	CF	DF
VO_2	6.8 ± 0.2	6.7 ± 0.2
VCO_2	6.4 ± 0.3	6.5± 0.3
V_e	690 ± 111	724 ± 110

We saw no significant differences in energy expenditure, as reflected by VO_2 and VCO_2 measurements, in either the recovering or acutely ill infants. These data do not support the hypothesis that DF significantly decreases work of breathing in neonates receiving IMV.

OF-93-078

PRESSURE REGULATED VOLUME CONTROL VS VOLUME CONTROL VENTILATION IN INFANTS AFTER SURGERY FOR CONGENITAL HEART DISEASE

Mary K. Dekeon RRT, Keith C. Kocis MD, Huda K. Rosen RRT, Kenneth P. Bandy RRT, Dennis C. Crowley MD, Edward L. Bove MD. University of Michigan, Mott Children's Hospital, Ann Arbor, Michigan.

Pressure regulated volume control ventilation (PRVC) employs a decelerating inspiratory flow waveform while maintaining a set tidal volume (Vt) and can provide equivalent alveolar ventilation with lower peak inspiratory pressures (PIP) than volume control ventilation (VCV). The purpose of this study was to determine if PRVC ventilation would provide equivalent alveolar ventilation with lower PIPs than VCV after surgery for congenital heart disease. Nine patients with repaired tetralogy of Fallot and atrioventricular septal defect were entered into the study. Patients returned from the operating room to the pediatric cardiothoracic intensive care unit and were placed on mechanical ventilation using a Siemens Servo 300 ventilator in VCV mode. Ventilator parameters were set with a Vt of 15-20 cc/kg, peak end expiratory pressure of 2-4 cm H_20, inspiratory time of 0.7 to 0.8 seconds, $FI0_2$ 0.8 to 1.0 and respiratory rate of 15-30 breaths/min to provide normal arterial blood gas (ABG) values (pH 7.35-7.45, $PaCO_2$ 35-45 torr, SaO_2 >95%). Following one hour of stabilization, hemodynamic measurements, ABGs, and airway pressures were recorded (VCV1). The mode of ventilation was changed to PRVC while maintaining the same ventilator settings. After a 30 min stabilization period, measurements were repeated. Patients were then returned to VCV and measurements repeated after 30 min (VCV2). PIPs were significantly lower in PRVC than VCV1 and VCV2. There was no significant change in oxygenation, ventilation, or hemodynamics. Thus, PRVC ventilation is useful in providing equivalent ventilation at lower PIPs than VCV in infants following congenital heart surgery.

	VCV1	PRVC	VCV2
PIP (cm H_20)	31	25*	31
P_{aw} (cm H_20)	7.8	7.7	7.7
pH	7.46	7.47	7.47
$PaC0_2$ (torr)	34.6	33.0	33.78
$Pa0_2$ (torr)	167	193	188
CI (L/min/m^2)	3.5	3.5	3.6

*$p < 0.05$

OF-93-090

STUDY OF FLOW-SYNCHRONIZED VENTILATION WITH THE VIP BIRD VENTILATOR.

Jeanette M Asselin BA RRT, Timothy Winn RRT, David J Durand MD, Kim Woodward MBA RRT. *From the Department of Respiratory Therapy and Division of Neonatology, Children's Hospital Oakland, California.*

Flow-synchronized ventilation (FSV) is a new mode of ventilation for neonatal patients. FSV synchronizes the ventilator breaths with the infant's respiratory efforts and allows the infant to choose his/her own respiratory rate and inspiratory time. Theoretically, FSV more effectively accommodates the labile ventilatory demands of neonates. We compared FSV via the VIP Bird ventilator with conventional time-cycled, pressure-limited ventilation (CV). We hypothesized FSV would decrease the infant's oxygen requirement, allow weaning of the ventilator pressures, decrease the infant's work of breathing, and improve the infant's level of comfort on the ventilator. Eligible infants were clinically stable on their current ventilator settings (via the Sechrist IV 100B), had no active barotrauma, and parental consent had been obtained. Patients were used as their own controls and were evaluated for eight-hours, four hours on FSV (via the VIP Bird) and four hours of CV (via the Sechrist IV 100B or the VIP Bird). Infants were randomized to order of study (FSV-CV or CV-FSV). Ventilator pressures were kept constant except when over-ventilation occurred. Patient's vital signs, pulse oximeter saturation and/or transcutaneous O_2 and CO_2, ventilator settings, activity level, and clinical work of breathing defined by retractions, synchrony and activity level, were monitored during both study periods. Eight infants (mean wt 1532 grams, mean postnatal age 25 days) were studied. On FSV, minute ventilation and mean airway pressure increased, while inspiratory time and respiratory rate decreased. No significant change was seen in SaO_2, $TcCO_2$, TcO_2, or required F_IO_2. Although FSV did not decrease F_IO_2 or peak inspiratory pressure requirements, it significantly decreased clinically apparent work of breathing and number of desaturation episodes, while allowing infants significantly more time in quiet sleep.

	CV	FSV	p value
HR	172 (14)	157 (11)	< 0.05
RR	59 (15)	52 (18)	ns
Paw	7.9 (0.6)	9.4 (1.1)	< 0.005
Tinsp	0.5 (0.1)	0.32(0.06)	< 0.0001
F_IO_2	0.35 (0.08)	0.32 (0.08)	ns
Desats(#)	94	23	< 0.007
Synchrony	27%	100%	< 0.0005
IntrcosRet	70%	5%	< 0.002
Subst Ret	86%	3%	< 0.0001

In conclusion, FSV via the VIP Bird is a promising new mode of ventilation for neonates. FSV is both very sensitive and responsive to the infant's changing ventilatory demands. These results warrant further prospective, randomized, controlled trials to address the potential benefits of FSV in specific patient populations and outcome (eg: survival and chronic lung disease). OF-93-103

RESPONSE OF INFANT VENTILATOR DEMAND VALVE SYSTEMS.

Masaji Nishimura, MD, Robert M Kacmarek, RRT, PhD, Sylvester Barker, LPN, Dean Hess, RRT, MEd. Massachusetts General Hospital, Boston, MA.

We evaluated the response of infant ventilator demand systems using a lung model with two small bellows inside an airtight box. **Methods:** Spontaneous breathing (SB) was simulated by generating negative pressure (NP) between the box and bellows, creating the followings; V_T 15, 30, and 45 ml; rate 30/min; T_I 0.65 s. The lung model was connected to each ventilator by a 3, 4, and 5 mm ETT. Four ventilators, Servo 300C, Baby Log, Bird VIP, and Bear Cub were evaluated. All were operated in PC with 0 or 5 cm H_2O PEEP. Flow triggering was used when available, and sensitivity was set as sensitive as possible without auto-cycling. Both upstream and downstream of ETT, pressure (Paw and Pca, respectively) and flow were measured. Bellows pressure (Palv), and pressure inside the box (Ppl) were also measured. All signals were recorded using a computerized CODAS system. The elapsed time (T_D) between the beginning of an inspiratory effort and the most negative pressure was calculated from tracing of Paw, Pca, Palv and Ppl. The initiation of inspiratory efforts were detected from Ppl tracing. All calculations were performed on at least 5 breaths. **Results:** The narrower the ETT, the greater the difference between Paw, and Pca or Palv, regardless of V_T or ventilator. However, maximum negative Paw did not differ significantly regardless of ETT. T_D tended to decrease as the size of ETT and V_T increased. 5 cm H_2O PEEP decreased neither maximum negative pressure nor T_D. T_D (msec) with the 4 mm ETT and ZEEP are listed below:

	Paw	Pca	Palv
V_T 15 ml			
Servo 300C	57.4±4.8	54.2±3.8	64.4±3.7
V.I.P. Bird	84.3±2.1	89.5±1.9	92.7±1.4
Bear Cub	85.5±3.5	88.1±2.0	95.3±3.9
Baby Log	91.3±5.1	95.9±4.3	100.3±2.9
V_T 30 ml			
Servo 300C	48.4±1.9	53.6±2.7	61.0±3.3
V.I.P. Bird	74.6±3.1	77.9±4.2	82.4±3.9
Bear Cub	75.2±1.9	78.0±1.6	87.9±2.5
Baby Log	79.9±4.7	84.3±6.7	91.3±7.4
V_T 45 ml			
Servo 300C	56.0±4.1	60.4±3.7	81.9±4.4
V.I.P. Bird	80.3±4.4	84.3±3.9	115.8±7.4
Bear Cub	77.9±4.6	91.5±4.1	126.6±3.4
Baby Log	87.7±3.3	90.7±3.3	107.9±4.8

Conclusion: Time delays, although short, were a substantial part of T_I. Imposed WOB in neonates can not be adequately accessed by monitoring Paw due to the ETT. Careful clinical study of the effect of patient triggering in neonates is needed.

OF-93-106

PEDIATRIC NEGATIVE PRESSURE VENTILATION IN CHRONIC RESPIRATORY FAILURE ASSOCIATED WITH RESTRICTIVE LUNG DISEASE-

Tina Givens, RRT, The Children's Hospital of Alabama; Raymond Lyrene, MD and Julie McDougal, RRT, MAE, The University of Alabama at Birmingham.

Noninvasive negative pressure ventilation is documented to be an acceptable alternative to tracheostomy or intubation with positive pressure or volume ventilation. We treated an 18 month old black female with chronic respiratory failure secondary to severe kyphoscoliosis, thoracolumbar myelomeningocele, Arnold Chiari malformation (hindbrain abnormality) and bronchopulmonary dysplasia. Delivered full-term via cesarean section, she weighed 2580 grams and required mechanical ventilation with 100% oxygen from birth. During the first nine months of life, she required frequent reintubation with the use of positive pressure and volume ventilation. Extubated periods varied in length from a couple of days to one or two months. During these periods, however, she required 50 -100% oxygen to maintain adequate oxygen saturations. During the first nine months of life, her capillary blood gases ranged pH 7.34 - 7.45, pCO2 50 - 78, HCO3 32 - 42, and Saturation 88 - 98. The need for chronic ventilation and a more stable airway suggested the insertion of a tracheostomy tube. At 9 months of age, neck exploration revealed that a conventional tracheostomy could not be safely performed. Magnetic resonance imaging at 14 months of age revealed anatomical distortion of the upper thorax and neck. The tracheal air column lay 1 cm posterior to the crossing of the brachiocephalic vessels. These vessels were somewhat superiorly displaced from their normal positions, crossing at approximately the level of the lung apices. This confirmed that the trachea was not safely accessible to a tracheostomy tube. Bilevel positive airway pressure (BiPAP) therapy (Respironics, Inc.) via mask ventilation was attempted. Because of her unusually small size (weight 10.26 Kg / height 62 cm), the patient could not be successfully stabilized due to the limitations of the equipment. We then attempted negative pressure ventilation via a Portalung (Portalung, Inc.) and a NEV-100 generator (Lifecare International, Inc). The patient was successfully stabilized on the following settings: IT 0.5, Rate 40 (while asleep) and 25 (while awake), negative pressure -20, base pressure -5, and sigh -26 at a rate of 1 breath/hour. Arterial blood gas revealed pH 7.4, pCO2 60, pO2 60, and HCO3 36. A nasal cannula was used at 1/4 - 1/2 liter per minute to maintain oxygen saturations at approximately 90%. She currently uses the above settings with stable arterial blood gases but spends 4 hours per 24 hour period out of the Port-a-lung. The use of noninvasive negative pressure ventilation for the management of this patient's chronic respiratory failure has allowed medical stabilization without the use of an artificial airway. Periods of time away from the Portalung have allowed greater mobility and increased access to multidisciplinary services.

OF-93-136

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ASSIST CONTROL (AC) VENTILATION FOR THE MANAGEMENT OF SEVERE CONGENITAL AIRWAY ANOMALIES

Dawne A. Savarese, RRT, David M. Habib, MD, Traci B. Mitchell, RRT, Medical University of South Carolina, Children's Hospital, Charleston SC

Advanced pediatric surgical and critical care skills have led to increased survival of children with congenital airway anomalies including external tracheal compression, malacia or stenosis. There is little literature describing weaning methods for ventilator dependent children. Common methods employed are SIMV, PSV, and CPAP trials. AC ventilation has not been previously advocated. A.H. was a 6 week old diagnosed at bronchoscopy with distal tracheal narrowing to 1.25mm. AH underwent thoracotomy, resection of the stenosis and insertion of a pericardial patch. Several extubation attempts were unsuccessful and a tracheostomy was performed. Thereafter, A.H. developed complications including severe distal tracheal malacia, vascular L mainstem bronchus compression, and a paralyzed R hemidiaphragm. This led to increased airway resistance, air trapping, limited diaphragmatic excursion, frequent tachypnea, tachycardia and diaphoresis. Because A.H. failed all methods of weaning that rely on effective respiratory muscle effort, AC ventilation was attempted. ABG's on SIMV of 14, V_T 120 ml, PEEP +6, PS+20, were pH 7.35, P_aCO_2 56, P_aO_2 113, F_IO_2 .30. ABG's on AC of 14, V_T 120 ml, PEEP +10, and F_IO_2 .30 were pH 7.49., P_aCO_2 37, P_aO_2 128. The pt's HR decreased from 148 to 126, RR from 56 to 40, and subjectively he appeared more comfortable. Serial CXR showed gradual resolution of L lung hyperexpansion and clearance of R lung atelectasis. AC appeared to improve ventilation by delivering consistent mandatory and triggered V_T while reducing the WOB associated with high airway resistance. We conclude: 1) children with airway anomalies associated with high flow resistance and inadequate respiratory muscle effort may benefit from AC. 2) We speculate that AC, in conjunction with flow synch, may be a more optimal method of weaning for these types of pediatric patients.

OF-93-149

PERFORMANCE OF HEATED-WIRE HUMIDIFIERS (HWH) USED IN RADIANT WARMERS (RW).

Robert M Lewis BA RRT; David Thelander BS, RRT, Zehava Noah MD, G. Kris Bysani, MD. Children's Memorial Hospital, Chicago, IL.

Incubators impair function of HWHs, increasing airway temperature (AT) and lowering relative humidity (RH). Low RH, even if absolute humidity is high, may cause endotracheal tube obstruction. We speculated that insulating ventilator tubing might prevent RW induced changes in AT and RH. Methods. We used a Fisher Paykel 730 HWH, a heated wire ventilator circuit (VC) (Marquest #155518); an Ohio Infant RW, and a Servo 900 C ventilator. AT and RH were measured at the patient connection with a Fisher Scientific hygrometer. The HWH temperature sensor was placed 15 cm outside the RW. The remaining 45 cm of the inspiratory tubing (IT) extended into the RW, and had no HWs. The expiratory tubing (ET), and the remainder of the IT had HWs. The HWH was set at an AT of 37 C, and the chamber control at -1. The RW was set at maximum. Ventilator total flow was 6 lpm. The IT was placed directly on the bed, and in contact with the ET. After 30 minutes, RH and AT were measured 5 times over 25 minutes. Then, the portion of the IT in the RW was covered with an aluminum coated polyester film (Johnson and Johnson "Rescue Blanket"); isolated from the ET; and suspended 5 cm above the RW bed. AT and RH were measured again. Results. When uncovered, AT was 40 +/-.7 C, and RH was 80 +/-3 %. When covered, AT was 35 +/-.6 C and RH was 100%. ($p<.05$, Mann-Whitney U test, for both AT and RH.) Conclusion. Covering the part of IT without HWs with reflective material, and avoiding contact with the RW bed and the heated ET improves RH and AT. However, as per manufacturer's recommendation tubing with HWs should not be covered.

OF-93-203

EFFECTS OF TRIGGERING SYSTEM AND ENDOTRACHEAL TUBE SIZE IN PRESSURE SUPPORT VENTILATION FOR NEONATES

Hideaki Imanaka, Akinori Uchiyama, Yuhji Fujino, Nobuyuki Taenaka and Ikuto Yoshiya
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INTRODUCTION: Pressure support ventilation (PSV) is now available for neonates. The object of this study is to evaluate effects of triggering system and endotracheal tube size on PSV performance using animal model.

METHODS: Under pentobarbital anesthesia, five New Zealand rabbits were tracheostomized with endotracheal tube, 3mm or 4mm ID. PSV was initiated with a VIP Bird ventilator. Ventilatory settings were as follows; CPAP of 0cmH_2O, PSV of 5cmH_2O and either pressure triggering (PT) or flow triggering (FT). Minimum trigger sensitivity was chosen not to cause autocycling. Flow rate, airway opening pressure, pressure at the tube (Ptip) and intraesophageal pressure (Pes) were recorded. After stabilization of 15 minutes, parameters was collected as follows, T_D (time delay from the start of inspiratory effort to the point when airway pressure returned the baseline value), T_{PS} (duration of PSV), Δ Ptip (downward swing in Ptip during inspiration), Δ Pes (swing in Pes during inspiration), PIP and RR (respiratory rate). Statistical analysis was performed with ANOVA followed by Scheffe's test.

RESULTS:	3-PT	4-PT	3-FT	4-FT
T_D (msec)	158*	162*	58	69
T_{PS} (msec)	355*#	246*	490#	386
ΔPtip (cmH_2O)	3.01*	2.40*	1.23	1.18
ΔPes (cmH_2O)	5.49*	3.94	3.85	2.54
PIP (cmH_2O)	4.21*#	5.03*	3.13	3.29
RR (/min)	35.7	37.7	34.5	37.9

* $P<0.05$ vs FT with the same tube size

# $P<0.05$ vs 4mm tube with the same system

CONCLUSIONS: Compared with pressure triggering system, flow triggering system showed a shorter trigger delay and a longer supported time and reduced inspiratory work. A wider endotracheal tube showed early termination of PSV.

OF-93-211

COMPARISON OF TRIGGERING SYSTEMS DURING PRESSURE SUPPORT VENTILATION (PSV) IN ANIMAL MODEL.

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Introductions: Triggering system of PSV needs to respond rapidly especially in neonate. We used a rabbit model to compare the effects of flow triggering and pressure triggering systems on trigger delay (T_D) and PSV support time (T_S).

Methods: Five supine anesthetized rabbits (2.7-3.2 kg) were studied. They were tracheostomized and 3.5mm endotracheal tubes were intubated. Respiratory flow rate ($\dot{V}$) and airway pressure (Paw) were measured. Diaphragmatic EMG was introduced from the sternum part of diaphragm through the upper median laparotomy incision. As an index of electrical activity, the amplitude of the integrated EMG signals, Edi was calculated. Transdiaphragmatic pressure (Pdi) was measured with a balloon placed in the mid-esophagus. Edi and Pdi were expressed as percentages of values during spontaneous breathing. VIPBIRD ventilator (Bird, USA) was used. The settings were CPAP mode with PSV 5 cmH_2O and PEEP 0 cmH_2O. Flow triggering sensitivity was set at 0.2 l/min(F 0.2), 0.5 l/min(F 0.5), 1.0 l/min(F 1.0), and 1.5 l/min(F 1.5). Pressure triggering sensitivity was set at -1.0 cmH_2O (P 1.0). We compared T_D and T_S. T_D was the duration between EMG ignition and a point at which Paw was returned to baseline value (point A). T_S was the duration between point A and a point at which Paw was started to decrease.

Results:	P1.0	F0.2	F0.5	F1.0	F1.5
T_D (msec)	194	73*	86*	107*	132*
T_S (msec)	282	472*	458*	438*	412*
%Pdi	72.0	48.0*	48.2*	49.1*	50.8*
%Edi	81.5	52.1*	54.8*	57.4*	59.9*

*: $p<0.05$ vs. P1.0

Conclusions: Since T_D was smaller and T_S was larger in flow triggering PSV, flow triggering PSV was more effective than pressure triggering PSV.

OF-93-212

ROLE OF FUNCTIONAL RESIDUAL CAPACITY CHANGES IN PRETERM INFANTS TREATED WITH SURFACTANT.

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Surfactant replacement is known to stabilize alveolar volume, improve functional residual capacity (FRC) and enhance gas exchange. End distending pressure (EDP) also has similar effects in preterm infants with respiratory distress syndrome (RDS). We report data on 6 intubated and ventilated preterm neonates (mean ± SD: BW: 1.05 ± 0.2 Kg, GA: 28 ± 0.4 weeks) who were ≥ 3 days of age and recovering from RDS after surfactant replacement. Lung functions were measured at EDP of 2 cmH$_2$0 by least mean squares technique; FRC at 2 and 5 cmH$_2$0 by helium dilution technique (solenoid valve switched automatically at end expiration by computerized technique). Base line data are:

Parameter	Mean ± SD	
Vt	6.5 ± 0.7	mL/kg
C$_L$	0.51 ± 0.20	mL/cmH$_2$0
C$_L$/kg	0.52 ± 0.12	(mL/cmH$_2$0)/kg
C$_L$/FRC	0.031 ± 0.013	(mL/cmH20)/mL
R$_T$	78 ± 27	cmH$_2$0/(L/s)
FRC at 2 cmH$_2$0	17.8 ± 5.6	mL/kg *
FRC at 5 cmH$_2$0	23.9 ± 6.0	mL/kg

These data show that significant (*$p<0.02$) reduction in FRC occurs with an EDP change. This change is about 2 mL/kg per cmH$_2$0 change in EDP and is often associated with changes in gas exchange. Thus, weaning EDP during recovery phase of RDS should be done cautiously.

(Supported in part by Pennsylvania Hospital Pediatric Fund)

OF-93-073

IN VITRO COMPARISON OF TWO SYSTEMS FOR FUNCTIONAL RESIDUAL CAPACITY (FRC) MEASUREMENT IN NEWBORN INFANTS.

Dennis R. Bing, RRT, Keith K. Holloman, RRT, Stephen J. Boros, MD, Mark C. Mammel, MD. Children's Hospital, St. Paul, MN.

We simulated spontaneous (SB) and mechanical breathing (MB) and measured several known levels of FRC using two devices commercially available for use in neonates. One used helium dilution (PANDA, Pulmonary Technology Industry, Inc.); the other used nitrogen washout (model 2600, SensorMedics, Inc.). We simulated SB with a Hans Rudolf 5510 series calibration syringe set at FRC values of 25, 45, and 65 ml using physiologically proportional tidal volumes at a respiratory frequency of 30/minute. We simulated MB using a time cycled pressure preset infant ventilator (VIP Bird, Bird Corporation) at a rate of 40/minute, inspiratory time 0.4 seconds, 0 PEEP and PIP adjusted to deliver appropriate tidal volume to a test lung inside a pressurized glass "thorax" which emptied completely on expiration. For MB we established standard FRCs of 15, 25, 45, and 65 ml using known volume dead space connectors between the test lung and FRC system valve. For nitrogen washout, we manually ventilated the test lung with a non self-inflating anesthesia bag using a continuous flow of 100% O2 at 8 lpm. We collected at least three FRC measurements at each known FRC level during 3 separate determination trials for MB and SB. Data are summarized in the following tables.

"SPONTANEOUS" BREATHING

Std FRC (mls)	Vt (mls)	N_2 FRC (mls)	N_2 Var (%)	He FRC (mls)	He Var (%)
25	10	24.4	-2.3	23.2	-7.2
45	15	45.6	1.4	40.7	-9.5
65	20	64.8	-0.3	58.7	-9.7
mean variances			-0.4		-8.8

"MECHANICAL" BREATHING

Std FRC (mls)	Vt (mls)	N_2 FRC (mls)	N_2 Var (%)	He FRC (mls)	He Var (%)
15	10	23.4	55.6	15.5	3.4
25	15	31.4	25.8	22.5	-10.1
45	20	49.8	10.6	38.9	-13.6
65	30	64.4	-0.9	65.5	0.7
mean variances			22.8		-4.9

These data show that both systems measure FRC in the neonatal range during SB with reasonable accuracy. However, He dilution was more accurate than N_2 washout during MB, especially at small FRC volumes.

OF-93-079

OUTPATIENT PEDIATRIC FLEXIBLE FIBEROPTIC BRONCHOSCOPY (FFB): A PROSPECTIVE EVALUATION

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Objective: To describe experience with outpatient pediatric FFB in terms of safety, length of procedure, and comfort. **Method**: Twenty-two patients (3 mo--24 year, mean 9.0 yr) underwent 30 FFBs in an ambulatory procedure center (APC) during a 5 month period. Twenty FFBs included transbronchial biopsy (TBB) sampling. Patients were monitored with ECG and pulse oximetry. Oxygen was given by nasal cannula to maintain SaO2 >90%. Complications were recorded during the APC stay and via telephone 24 hours after discharge. Calls were made to the parent and to children >5 years of age. **Results**: All FFBs were completed without dysrhythmia or sustained hypoxemia. Specimens adequate for histopathology were obtained in 19 of 20 TBBs. Complications were seen in the APC in 5 cases: increased cough (3) and transient desaturation (2). Air leak or hemothorax was not seen. All patients were discharged after the procedure. One patient, a 7 month old with asthma, was readmitted 28 hours after FFB for wheezing. Procedure length was 11.3 ± 4.6 min for FFB and 25.8 ± 4.8 min for FFB with TBB. Mean time from admission to discharge was 152 min (range 85-235 min) with no difference between TBB and non-TBB. All patients received IV Midazolam (.249 ± .082 mg/kg) and topical Lidocaine (3.1 ± 1.5 mg/kg). Twenty-nine patients received IV Fentanyl (2.755 ± .957 mcg/kg). Correlation between total sedation dose and admission length was not significant (p=0.25). Follow up calls were completed after 29 of 30 FFBs. Late symptoms reported were cough (18), sore throat (8), fever (6), and wheezing (5). Four of 16 patients >5 years could recall details of the procedure: bronchoscope being introduced (1) or removed (2) from nose, and suctioning of the mouth (1). **Conclusions**: Pediatric FFB, including TBB sampling, can be performed safely and expeditiously in an outpatient setting. IV sedation can be titrated to provide comfort without prolonging the outpatient stay.

OF-93-087

CHANGES IN VD/VT RATIO AND DYNAMIC LUNG COMPLIANCE IN INFANTS WITH CONGENITAL DIAPHRAGMATIC HERNIA

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Introduction: Dynamic lung compliance (Cdyn) has been used to monitor pulmonary changes during the duration of ECMO. Recent data from our institution have shown that the VD/VT ratio steadily improves during ECMO and is a more reliable predictor of ECMO duration than Cdyn. We now compare VD/VT to Cdyn in the diaphragmatic hernia patient (CDH) prior to and during ECMO to evaluate its usefulness in predicting ECMO requirement, ECMO duration, and outcome in CDH. **Methods:** VD/VT measurements were determined using a modified Bohr-Enghoff method. Serial VD/VT ratios and Cdyn were obtained upon admission, prior to ECMO, and throughout the ECMO course. All measurements on ECMO were made during routine brief separations from the circuit during which times patients were sedated, paralyzed, and ventilated on standard settings. **Results:** Sixteen CDH infants who required ECMO and 9 who did not were evaluated. There was a significant difference in initial VD/VT between patients requiring ECMO and in those not requiring ECMO (p=.004). During the ECMO course, VD/VT remained constant even though compliance steadily improved in all patients. There was no significant difference in pre-ECMO VD/VT or Cdyn between survivors and nonsurvivors. The constant VD/VT calculated prior to removal from ECMO, however, was significantly lower in survivors compared to nonsurvivors (p=.03) while Cdyn was not significantly different. **Conclusion:** We conclude that the significant difference in VD/VT ratio between patients requiring ECMO and those who did not may make this a useful tool in predicting ECMO requirement in the future. A recent series of neonates other than CDH demonstrated that the VD/VT ratio improved throughout ECMO and was a reliable predictor of ECMO duration. This change was thought to result from steady improvement in pulmonary capillary blood flow. In the current study concerning CDH only, VD/VT remained constant throughout the ECMO course while compliance improved. This would imply that pulmonary blood flow in CDH remains constant. Furthermore, the fact that there was a significant difference in VD/VT between survivors and nonsurvivors also suggests that this may be a useful tool to predict the degree of vascular hypoplasia in the CDH infant.

OF-93-116

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MEASURED IMPOSED WORK OF BREATHING THROUGH FIVE NEONATAL FLOW SENSORS.

Kelvin D. MacDonald CRTT, Bill Wagner RRT, Cyndy Miller RRT. Kaiser Permanente Medical Center, Los Angeles.

Introduction: Utilization of airway flow sensors in neonatal ventilation is increasing as mechanics monitoring and patient triggered ventilation becomes more prevalent. However, a number of clinicians have expressed concern about additional imposed work of breathing (WOB) with these devices. Employing a bench model of neonatal breathing, we sought to measure patient imposed work with various examples of sensors in comparison with patient imposed work with the ETT alone. **Methods:** A pump that generated a modified sine flow wave form was used in conjunction with a double infant drive/slave lung arrangement (Michigan Instruments, TTL) with a system compliance of .001 L/cm H2O, and no additional resistor. A BICORE CP-100N pulmonary mechanics monitor incorporating a differential pressure pneumotachometer was affixed to the slave lung, to measure pressure, flow, and volume. All measurements were made at the distal end of the test apparatus to simulate "carina" measurements. The rate and tidal volume of the pump was varied to achieve peak flow rates of 40, 80, and 170 mL/second. Sensors from the BIRD Partner, BICORE CP-100N, Bear NVM-1, Drager BabyLog, and Hans Rudolph Neonatal whose deadspace ranged from .07 mL - 1.5 mL, were tested. Each was attached to the model directly, and again with a 10 mm long 2.5 mm I.D. ETT, and a 13 mm long 3.5 mm I.D. ETT. Values for work of breathing at the "Carina" was recorded after a 30 breath average was reached. **Results:** The pt WOB in grams per cm @ differing flow rates appear in the table:

ETT • (flow)*10	no ETT (4) (8) (17)	2.5 mm ETT (4) (8) (17)	3.5 mm ETT (4) (8) (17)
no sensor	(1) (7) (37)	(16)(118)(520)	(4)(32)(188)
Bear	(2) (12) (86)	(16)(122)(532)	(5)(40)(225)
BICORE	(2) (12) (66)	(16)(124)(531)	(5)(41)(222)
Bird	(3) (19) (70)	(16)(125)(527)	(5)(44)(222)
Drager	(2) (12) (74)	(16)(128)(538)	(5)(40)(220)
Hans Rud.	(2) (10) (61)	(16)(122)(525)	(4)(38)(214)

Conclusions: As flow increased, work increased with all sensors tested. However, as the ETT contributed the majority of measured imposed WOB, we conclude that neonatal flow sensors do not adversely affect work in our model. Factors including differences in mechanical deadspace of the sensors and the effect of humidity and secretions may be clinically significant and were not considered in this evaluation. Further investigation to determine clinical significance is warranted.

OF-93-130

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SURFACTANT (S) ADMINISTRATION IMPROVES DYNAMIC COMPLIANCE (DC) AND ALVEOLAR-ARTERIAL (A-a) OXYGEN GRADIENTS IN THREE CRITICALLY ILL CHILDREN

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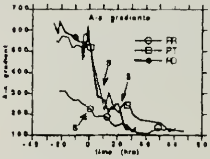
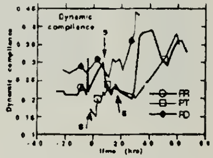
There has been increasing use of exogenous surfactant for pediatric and adult pulmonary diseases. Animal models have demonstrated abnormal surfactant function following acute lung injury. Alveolar stabilization by S is reflected by changes in oxygenation and compliance. We retrospectively reviewed the A-a gradients and DC measurements of three critically ill pediatric patients with acute ARDS in whom S (Survanta) improved pulmonary function. Three male children aged 1 (PT), 16 (RR), and 22 (RD) months required mechanical ventilation (MV), sedation and continous paralysis after massive aspiration of gastric contents into their lungs. For PT,RR, and RD, ventilator settings prior to S were FIO2: 1.0, 0.55(on ECMO, 55% bypass), 0.89; PEEP (cmH20): 6, 12, 10; MAP (cmH20): 21, 20, 24; and MV duration (hrs): 41, 216, 36. CXR's of all three patients were consistent with ARDS prior to surfactant therapy. Total dose of S (25mg/100ml) was 4ml/kg given separately as 1ml/kg aliquots into four lung quadrants. Each child received three doses every 8-12 hours.





Serial A-a gradients for PT and RD showed marked improvement after one dose of S . Early improvement of oxygenation was less apparent for RR due to reduced FIO_2 requirements and lower baseline A-a values while on ECMO. Thereafter, all showed gradual decrease of their A-a gradients. Serial DC measurements showed small changes after inital and second doses of S; however, following the third dose all patients demonstrated large increases in DC. RR and PTwere extubated 7 and 12 days post S. RD expired after prolonged MV and severe pulmonary fibrosis. Conclusion: 1) Exogenous surfactant produced beneficial changes in pulmonary function in these pediatric patients. 2) Improved oxygenation after S, reflected by A-a gradient, is detected earlier than changes in dynamic compliance. 3) At least 3 doses of S are necessary before sustanined changes in both dynamic compliance and oxygenation are observed. Speculation: 1) Severe pulmonary aspiration is a subset of ARDS that may benefit from S. Animal models and prospective human studies in these types of critically ill patients are necessary to evaluate the efficacy and dosing of S therapy.

OF-93-148

REPRODUCIBILITY OF BEDSIDE PEDIATRIC PULMONARY CART

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New computerized systems for measuring pulmonary mechanics of newborns at the bedside should improve the match between mechanical ventilators and the mechanical needs of newborns with a variety of pulmonary disorders. The purpose of this study is to evaluate the variability in short term pulmonary mechanics measurements using the SensorMedics 2600 computerized pulmonary function cart. Ten sets of measurements were made on newborn infants receiving conventional mechanical ventilation. Four consecutive breaths were gathered in each set of measurements. The system was then removed from the patient circuit, and the report was printed. Five to ten minutes after completion of the first study the pneumotachometer was again placed between the ventilator circuit and the endotracheal tube, and a second set of four breaths was collected. The results were printed out and results compared to the first study. Results were analyzed by calculation of the percent change in tidal volume (Vt), measured inspiratory time (Ti), peak inspiratory pressure (PIP), positive end expiratory pressure (PEEP), dynamic compliance (Cdyn), peak tidal expiratory flow to tidal volume ratio (PTEF-Vt), peak tidal expiratory flow (PTEF), from the first test to the second test. In each test average values for the four breaths were calculated and used for percentage change. Results of study are shown.

Flow-Volume loops		Pressure-Volume loops	
Vt	2.09%	Vt	4.28%
PTEF/Vt	5.89%	Ti	.59%
PTEF	3.01%	PIP	.34%
		PEEP	2.42%
		Cdyn	6.38%

Analysis of a test lung, using four different ventilator settings revealed 0% difference in the Vt measured. Results observed using the test lung verifies the excellent accuracy of the SensorMedics 2600 Pulmonary Cart. Although the variability of pulmonary mechanics measurements on newborns receiving mechanical ventilation is still very small, these small changes may represent real changes in the interface between patient and mechanical ventilation. Such variation must be taken into account when examining the effects of clinical maneuvers upon newborn pulmonary mechanics.

OF-93-190

VARIABILITY OF PASSIVE RESPIRATORY MECHANICS DURING HIGH FREQUENCY OSCILLATORY VENTILATION (HFOV)

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Diagnostic equipment and techniques have been developed for monitoring conventional ventilator therapy and pulmonary function parameters. We have previously presented a modification of the conventional technique for measuring passive respiratory mechanics with the SensorMedics 2600 Pediatric Pulmonary Cart for use in infants on the SensorMedics 3100 HFOV. The modification of the conventional technique for passive respiratory mechanics measurements requires several changes to the valve assembly. In performing 32 studies on seven HFOV patients, we have found it to be very well tolerated. We performed six to ten separate occlusions during each test. The data collected is statistically analyzed with a mean and coefficient of variation reported. The coefficient of variation has remained between 6.3 and 14.7% for Crs values and 10.7 and 27.3% for Rrs values. The limitation of this modified technique is that occlusion can occur anywhere during inspiration or expiration of the HFOV breath. This appears acceptable due to the small amount of volume change with each breath. These studies have shown that the technique of measuring passive respiratory mechanics during HFOV is as reproducible as it is when performed during conventional mechanical ventilation. Since this technique is non-invasive and well tolerated it can be easily applied to even the very sick infant requiring HFOV. We feel the value for Crs at a specific mean airway pressure (MAP) may be of most value for clinical management of HFOV. We hypothesize that Crs reflects lung volume and the clinical usefulness of this technique lies in correlating it with the other diagnostic techniques employed during HFOV such as chest x-ray and blood gases. When a low lung volume is recognized on chest x-ray MAP can be incrementally increased with serial measurements of Crs until a significant improvement in Crs is measured. We feel this technique may be useful in the clinical management of patients on HFOV with further experience.

OF-93-198

THE IMPACT OF 96-HOUR VENTILATOR CIRCUIT CHANGES ON RATES OF VENTILATOR-ASSOCIATED PNEUMONIA AND COSTS.

R. Eller, BS, RRT, K. Kennedy, BS, RRT, P. Weber, RRT, T. Nadzam, RRT, J. Vargo, BSN, M. Nield, PhD, RN.

We hypothesized that decreasing routine ventilator circuit changes from 48 hours to 96 hours would result in significant cost savings without increasing the rate of nosocomial pneumonia. Previous studies have shown no increase in nosocomial pneumonia rates with prolonged ventilatory circuit changes (Dreyfuss et al, ARDS: 143, 738-743). A quasi-experimental design with one pre-post measurement was used. The rate of ventilator-associated pneumonia for a 3 month period with 96-hour circuit changes was compared to the same 3 month period with 48-hour circuit changes in the Surgical Intensive Care Unit (SICU) of a 415 bed community hospital. Rate was defined as the number of ventilator-associated pneumonia/number of ventilator-days x 1000. The source of the ventilator-associated pneumonia rates was the Center for Disease Control's National Nosocomial Infection Surveillance. The cost of ventilator-circuit changes (material and personnel) was also compared for the same period. Data for the 96-hour circuit changes are reported after 100% compliance with the change was assured. The ventilator-associated pneumonia rates and costs for 1991 and 1992 for the 3 month period are listed below.

SICU 3-Month Pneumonia Ventilator-Associated Rate and Costs

	1991	1992
Pneumonia Vent Assoc	7	8
Patient Vent Days	465	591
Infections rate	15.1	13.5
Costs	$13,576	$7,760

We conclude that the change in practice from 48 hour to 96 hour circuit changes was not associated with an increase in ventilator-associated pneumonia in the SICU. The findings of no adverse effect and cost savings support the hospital's practice of 96 hour circuit changes.

OF-93-009

CONTAMINATION OF TREATMENT NEBULIZERS AND FREQUENCY CHANGE.

Jodeen Farnsworth Mann, B.S., R.R.T., Barbara Hurlbert, M.D., University of Nebraska Medical Center, Omaha, Nebraska.

Respiratory Therapy cleaning and sterilization procedures seem to have come full circle from departmental cleaning of most equipment to utilization of single patient use supplies. In light of recent studies which have examined ventilator circuit use beyond 24 hours,we conducted a study to examine contamination of treatment nebulizers. Methods: Patients who were receiving aerosol therapy via a handheld nebulizer with a mouthpiece were selected to participate. Baxter Airlife "Misty Neb" nebulizers were placed in specially marked plastic bags with a drawstring-type closure. After treatment, therapists shook excess moisture from the nebulizer and returned it to the bag. The medicine cup of the nebulizer was swabbed at 24 and 48 hours. Results: Fifty-two nebulizers from 42 different patients were cultured. None of the 52 nebulizers were found to be contaminated at 48 hours, while two nebulizers had positive cultures at 24 hours. The first of these grew normal respiratory flora. The second grew coag negative staph, a possible contaminant secondary to sampling error. Both nebulizers cultured negative at 48 hours. Using the Z test for statistical analysis, [even with 52 consecutive cultures (observed frequency = 0% at 48 hours)], there remains a 5% possibility that the true frequency of contamination could be as high as 5% in a much larger sample of patients. Conclusion: This study suggests that extending handheld nebulizer use beyond 24 hours may be acceptable.

OF-93-034

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NOSOCOMIAL PNEUMONIA (NP) DURING ADULT MECHANICAL VENTILATION (MV) IN A LARGE UNIVERSITY TEACHING HOSPITAL.

Ed Burns, RRT, Dean Hess, MEd, RRT, David Romagnoli, MS, RRT, Robert Kacmarek, PhD, RRT. Massachusetts General Hospital, Boston, MA.

NP is a recognized complication of MV. We conducted this study to determine the NP rate associated with MV in a large urban university teaching hospital. METHODS: The study period was November 1, 1992, to April 30, 1993. Patients were ventilated using Puritan-Bennett 7200 ventilators with heated cascade humidifiers; neither closed feed humidifiers or heated circuits were used. Closed suction was used with selected patients, but not routinely. Ventilator circuits were changed every 48 hr. Circuit caps were provided for all patients; it is our practice to cap the ventilator patient connection when the circuit is disconnected and to cap the resuscitator patient connection when it is not in use. In-line water traps were used routinely to evacuate condensate without opening the circuit. NP was determined prospectively by nurses trained to identify NP using CDC criteria (J Infect Control 1988;16:128). NP was considered MV-related if it occurred after 48 hr of MV and within 48 hr of discontinuation. Patients and their associated MV days were determined from the computerized records of the respiratory care department. Using CDC recommendations (Am J Med 1991;91:185S), NP were segregated according to medical or surgical unit. NP rates were further segregated by MV within or outside the ICU. Per CDC recommendations, NP rates were determined using 1000 MV days as the denominator. Statistical significance was determined using z-test for proportions. RESULTS:

	patients	days	NP/1000
all medical	381	3068	2.93
floor/medical	90	741	4.05
ICU/medical	291	2327	2.58
all surgical	1325	6791	11.34
floor/surgical	249	1650	4.85
ICU/surgical	1076	5141	13.42
TOTAL	1706	9859	8.72

There were significant differences in NP between medical and surgical units ($P<0.001$), surgical floor and ICU ($P=0.006$), and ICU medical and surgical ($P<0.001$). There was no significant difference in NP between medical floor and ICU ($P=0.80$) or floor medical and surgical units ($P=0.95$). CONCLUSIONS: These prospectively determined NP rates in adult MV patients are lower than CDC reported rates (Am J Med 1991;91:185S), and were very low in medical patients. To our knowledge, NP rates in MV patients outside the ICU have not been previously reported, and we found these to be very low. We credit our low NP rates to aggressive surveillance and a QA program that closely monitors NP rates.

OF-93-064

EVALUATION OF THE FILTERING ABILITY OF THE LAERDAL RESUSCI™ FACE SHIELD

Dean Hess, M.Ed., RRT, Dan Fisher, RRT; Massachusetts General Hospital, Boston MA

We conducted this study to evaluate the effectiveness of the filter material in the Laerdal Resusci™ Face Shield. This device is designed to provide a barrier during exhaled gas ventilation. METHOD: Five filters were challenged with albuterol aerosol produced by a medication nebulizer (Baxter Airlife Misty™ Nebulizer). This methodology was used due to the dense aerosol produced, the relatively small particle size produced, and the ability to measure albuterol spectrophotometrically. Albuterol concentrations were determined at 278 nm using a Beckman DU-30 spectrophotometer. A standard curve was constructed, from which albuterol concentrations were determined from absorbance. Particle size distribution of the test aerosol was determined using a seven stage calibrated cascade impactor (Intox Model 02-140), and found to be a MMAD of 3.6 μ and a GSD of 2.6 μ. A 0.5 mL solution of 0.5% albuterol was diluted with 3 mL of saline, and the nebulizer was powered with 8 L/min O_2. A cross-flow of 20 L/min was directed across the nebulizer into the filter being tested. Cotton wadding was placed distal to the filter to trap albuterol that penetrated the filter. A sample time of 3 min was used. Albuterol was extracted from the filter and the cotton using saline, and analyzed spectrophotometrically. The amount of albuterol present on the filter was added to the amount of albuterol on the cotton distal to the filter, and this was divided into the amount of albuterol on the cotton to determine the percent penetration through the filter. RESULTS: The penetration of albuterol through the 5 filters ranged from 0-2.1% (median 1.9%). No albuterol penetrated the filter in 2/5 filters. CONCLUSIONS: The particle penetration through these filters was low for the test conditions used in this study. This device should be a useful barrier device during exhaled gas ventilation. Full protection of the rescuer is probably not possible without the use of a device such as bag-valve-mask, but such devices are too difficult to use by untrained persons. Further work is needed to evaluate the effectiveness of this device to deliver an adequate tidal volume during exhaled gas ventilation.

OF-93-065

REUSABLE MECHANICAL VENTILATOR CIRCUIT COST ANALYSIS

William Backes BS RRT, Paul Montague BA RRT, University of Wisconsin Hospital & Clinics, *Madison, Wisconsin*

In a effort to reduce costs of patient care, University of Wisconsin Hospital (UWHC) Respiratory Care Services (RCS)converted from disposable to reusable ventilator circuits in the summer of 1979. Cleaning of reusables was facilitated by the move into a new facility April 1, 1979. A larger reprocessing area was built into Central Supply (CS) with a central workforce. The new center is able to reprocess a large volume of equipment and supplies from Anesthesia/OR, RCS, and other areas of the hospital. Expenses were compiled for 13 consecutive fiscal years (July1-June 30) starting with fiscal 1980. Included in the costs are pediatric and adult tubing, water traps, ET adapters, misc. adapters and CS Reprocessing Labor. CS Reprocessing assembles the circuits, so no RCS labor is included for comparison with disposable circuit costs. Also, labor to restock circuits is not included, since it would be the same for reusable or disposable circuits. During fiscal years 1980-83 ventilator circuits were changed daily. Circuit changes were extended to every other day in July 1984 and to 7 days in March 1992. Only silicone reusable tubing was used until July, 1985, when Hytrel tubing was added. Hytrel tubing costs substantially less than silicone and is lighter. It has worked very well for adult tubing, but we continue to use silicone tubing for infants. Infant Hytrel tubing had a higher rate of breakage and had more condensate problems than silicone tubing. Over the thirteen year span, the cost for reusable circuits per circuit change ranges from $1.86 to $3.28, with an average of $2.46. Annual circuit changes range from 3200 to 6000. Annual ventilator days range from 3421 to 10241. Using a typical figure of $6.00 per disposable ventilator circuit, UWHC has saved approximately $375,000 in the past 13 years. Annual savings will be less for fiscal 1993, because 7 day circuit changes will reduce labor charges. Savings are expected to be $8-10,000 for fiscal 1993.

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EXAMINATION OF OXIMETER NON-DISPOSABLE PROBE DISINFECTION TECHNIQUES-Marty Wilkins BS RRT, Stan Thornton RRT, St Vincent Hospital and Medical Center, Portland OR.

Introduction: The practice of using the same pulse oximeter probe on several different patients is a common practice in many hospitals across the country. This presents the potential for nosocomial infection. Most manufacturers of reusable pulse oximeter probes recommend disinfecting with soap and water. A study was undertaken to determine the efficacy of this practice, as well as, to examine other methods of disinfection. **Methods:** A study of three infectious bacterial organisms was performed. We selected finger clip probes and straight bandage probes. The test procedure consisted of dipping a gloved finger into a suspension containing 1 x 10^{x6} organism/ml of each of the following organisms: *Staphylococcus aureus*, *Pseudomonas aerugeinosa*, and *Candida albicans*. Controls consisted of cultures of contaminated probes prior to disinfection. Three different disinfecting techniques were used for each organism. First, the probes were disinfected using soap and water by mechanically scrubbing for 30 seconds. Second, the probes were mechanically scrubbed for 30 seconds with 70% isopropyl alcohol on the surface that was in contact with the inoculated finger. Finally, each probe was saturated with "256 Q", a quantanary ammonia, and allowed to air dry for 10 minutes before culturing. The probes were swabbed with a moist sterile cotton swab which was used to even seed agar plates containing 5% sheep blood agar. Inoculated plates were incubated for 2 days and examined for degree of organism inhibition relative to disinfecting method. Data is summarized in the following table:

S. aureus	Soap/ water	Isopropyl alcohol	256 Q
% Inhibition	95%	100%	100%
P. aerugeinosa			
% Inhibition	50%	100%	95%
C. albicans			
% Inhibition	50%	100%	100%

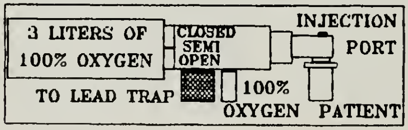
Conclusion: Soap and water was not successful in disinfecting any of the probes in this study while 70% isopropyl alcohol adequately disinfected all the probes, and 256 Q disinfected all the probes execpt those exposed to Pseudomonas. Based on our findings, we conclude that a antibacterial agent in association with mechanical scrubbing, as was employed with 70% isopropyl alcohol, is effective in disinfecting pulse oximeter probes.

OF-93-166

REBREATHING TECHNIQUE FOR PERFORMING XENON LUNG SCANS ON INTUBATED PATIENTS

Howard Mc Donald CRTT, Bahram Redjaee MD, William Higgins MD. Southern Maryland Hospital Center, Clinton, Maryland.

The radioisotope Xenon 133, has long been recognized as a safe, cost efficient, non-invasive means for performing pulmonary ventilation scans. Perfusion scans can detect pulmonary emboli, but need to be compared with pulmonary ventilation scans to differentiate between pulmonary embolus and other pathological lung conditions such as asthma, bronchitis, emphysema, tumors, or pneumonia. These scans were normally performed on intubated patients using radioaerosols because Xenon 133 needs a closed sealed circuit capable of rebreathing as well as for scavaging radioactive gases to a lead trap. Flow must be controlled for the needed rebreathing phase of the Xenon 133 isotopes. This method is used on all intubated patients using the Pulmonex™ (Atomic Products) as a lead trap left in its Washout position, using it for collection of radioactive isotopes. We created this technique for all intubated patients using a device now called Scanbag, (King Systems) consisting of a modified Jackson-Reese Anesthesia Bag with a injection port, 3 liter bag, oxygen inlet and tubing, a twist exhalation valve and tubing controlling the scavenging radioactive gases to the Pulmonex™. This device and technique allows for the assessment of all phases of regional lung ventilation, Single Breath, Rebreathing, Equilibrium and Washout. Technique: (1) Fill bag with 3 Liters of 100% O_2, (2) Turn off oxygen and close twist valve, (3) Inject Xenon in resealable port, (4) Give Single Breath and hold for 10 seconds, (5) While the patient is in rebreathing phase, ventilate the patient normally for WashIn phase for 3-5 minutes or until Equilibrium is reached, (6) Open twist valve to Semi position and turn oxygen on to begin WashOut phase, this takes approximately 5 min. or until clearance of activity from the lungs, (7) Place patient on ventilator for Perfusion Scan, (8) Dispose of device with radioactive waste. This technique has been used on over 30 intubated patients with reproducible results enabling us to provide an intubated patient a complete V-Q scan for a concise diagnosis.



OF-93-004

RELATIONSHIP BETWEEN FEV_1 AND $FEF_{25\%-75\%}$ IN SUBJECTS HAVING EXERCISE-INDUCED AIRWAY OBSTRUCTION

Robert A. Brown, Ronald Sorkness, Chris Sorkness, William Busse. Pulmonary Function Laboratory and Allergy Research, University of Wisconsin Hospitals and Clinics, Madison, WI.

$FEF_{25\%-75\%}$ (FEF) is a measure of airway obstruction (AO) that may be more sensitive to peripheral AO, than FEV_1, however it is thought to be less reproducible than FEV_1. We used data obtained in a pharmaceutical clinical research trial involving subjects with exercise-induced airway obstruction (EIAO) to assess the reproducibility of FEF measurements and to assess the relationship between changes in FEF and FEV_1. All nineteen (6F and 13M; 21-34 years), medication free, asymptomatic asthmatics, with baseline FEV_1 of 70-120% of predicted, had an exercise-induced fall of FEV_1 of 20-50%. Six exercise challenges were studied, with and without bronchodilator drug treatment, and 50 pairs of spirometric measurements were obtained over the course of the studies, in each subject. For each subject, all measurements were done in the Pulmonary Function Laboratory, at UWHC, on the same spirometer, which was calibrated each day, prior to testing. All subjects were tested in the sitting position and were carefully instructed, coached and motivated during testing. For paired measurements, at a single point in time, reproducibility was similar for FEF as for FEV_1 (FEV_1: $r^2 = 0.97$ and SEE = 2.9; FEF:$r^2 = 0.98$ and SEE = 4.4); differences between paired measurements of FEF tended to be larger when AO was present {decreased FEV_1} (Spearman $r = -0.29$, $p < 0.001$). For each subject, FEF was found to change exponentially with changes in FEV_1. For changes in AO induced by exercise and bronchodilator drugs, log(FEF) was highly correlated with FEV_1 ($r^2 \geq 0.93$ for each subject) and was linear over the entire range of FEV_1. We conclude: (1) FEF reproducibility was similar to that of FEV_1, (2) FEF varies exponentially with FEV_1, which suggests that predictive equations and diagnostic criteria based on log-transformed FEF data may be more precise than those based on FEF in standard units of flow, and (3) the high level of correlation between FEV_1 and FEF indicates that the two tests detected the same changes in AO and therefore implies that peripheral AO, which affects FEF to a greater extent than FEV_1, is not a significant component of EIAO.

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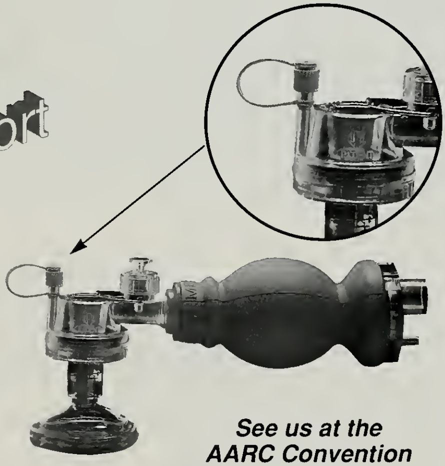

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COMPARISON BETWEEN SPIROMETERS OF VARIOUS LABORATORIES IN THE NEW ENGLAND AREA

by C. Burnes, Brigham and Women's Hospital, Boston, MA.

Standardization between spirometers is a current issue for Quality Assurance. The New England Association of Pulmonary Technologists addressed this issue by testing trained PFT technicians on spirometers of 7 different labs. Comparisons were made between FVC's and between FEV$_1$'s obtained at the different labs to demonstrate the degree of consistency. Each institution provided a trained tester. We followed the ATS protocol for a good test and for choosing the best trial. To correct for intra-subject variability, % variability was calculated between the 3 trials each subject performed at each institution. We also measured the coefficient of variation (CV) between the best FVC's (and best FEV$_1$'s) each subject (n=11) obtained at the total number of institutions where he/she was tested. Results of the % variability calculations are represented in Table 1 and comparison of CV's to other studies of this nature are in Table 2.

CRITERIA	FVC	FEV$_1$
3 trials within 5%	98/108 (90.7%)	94/108 (87.0%)
% within 1 S.D.	100/108 (92.6%)	97/108 (89.9%)

Table 1: Criteria met by % variability between the 3 trials each subject performed at each institution (n=108).

	Burnes *(n=11)*	Wanger[1] *(n=15)*	Kangalee[2] *(n=1)*
LOW CV			
FVC	0.63	2.70	3.80
FEV$_1$	1.96	2.90	3.80
HIGH CV			
FVC	4.50	4.10	3.80
FEV$_1$	4.07	4.80	3.80

Table 2: CV's compared between 3 different studies (n=# subjects).

With trained subjects we were able to demonstrate results that are consistent with other studies measuring CV between FVC's and FEV$_1$'s . In conclusion, it is shown that interlaboratory variability between these parameters is relatively low.

---

[1] Wanger, Jack. Respiratory Care. Dec. 1991.
[2] Kangalee, K. Michael. Chest. Jan. 1992.

OF-93-011

Title: FIVE-YEAR RETROSPECTIVE ANALYSIS OF PULMONARY FUNCTION (PF) DATA FROM ORTHOTOPIC HEART TRANSPLANT (OHT) PATIENTS

Authors: TB Op't Holt EdD RRT, CL Op't Holt MS RN, RC Starling MD, PD Myerowitz MD.

Introduction: The extent of changes in lung function following OHT is controversial. The literature reveals that the FVC may increase due to decreased lung water, improved compliance, and/or increased space available following the replacement of a dilated heart with one of more normal size. Another report states that the D$_L$CO is decreased following heart transplantation. We retrospectively studied the PFs of 38 OHT patients over as much as a five year period. We subdivided the population into ischemic and dilated cardiomyopathy groups (per preoperative diagnostic evaluation) and a group of 10 patients who had the poorest PFs. We compared pre- and postoperative values for volumes, flows, and diffusion via paired t-test and repeated measures analysis of variance. All PF tests conformed to ATS specifications. **Results:** We found significant differences ($p<.05$) in percentage predicted from preoperative values at one year postoperatively in the following parameters: FVC, D$_L$CO/Va, D$_L$CO/Hb and RV/TLC. However, when comparing preoperative values through 2-5 years postoperatively, TLC transiently increases significantly ($p < 0.05$) to the second year, then decreases significantly back to preoperative values. The FVC increases significantly by the second year postoperatively, then decreases, but remains significantly higher than preoperatively at five years. The D$_L$CO/Va decreases significantly through the third year postoperatively. **Conclusions:** We concur with others that the FVC increases and that diffusion capacity decreases following OHT, but we cannot derive a mechanism from our study. While it may be useful to perform PFs to assess operative risk, we cannot justify routine postoperative PF testing for the sole purpose of following the change in FVC or TLC. Studies of diffusion may be useful for tracking infectious or cyclosporine-induced pulmonary injury. Further study is indicated to determine the effect of weight changes and honest smoking cessation following transplant on PFs.

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DO PRESSURE DRESSINGS INCREASE THE INCIDENCE OF HEMATOMAS FOLLOWING ARTERIAL PUNCTURES?

Tom Taylor RRT, Jennifer Anderson RRT, Lisa Previte RRT, Sandee Cegielski RRT, Lennard Specht MD, Jerry L. Pettis VA Medical Center; Dept. of Allied Health Professions, Victor Valley College and the Dept. of Medicine Loma Linda University. Loma Linda CA. 92357

Hematomas are a known complication of arterial puncture. As part of our quality improvement program we assessed the rate of hematoma after arterial puncture with and without the use of a pressure dressing. A subset of patients were selected at random over a 15 month period. For 3 months, in addition to direct pressure, all arterial puncture sites were treated with a pressure dressing. For the next 12 months, the arterotomy site was treated by direct pressure and the application of a non-pressure dressing. Arterial Puncture sites were examined less than 24 hours following a single arterial puncture. A hematoma was judged to be present if an area of induration $\geq$ 10 mm in diameter was present. Throughout the duration of the study all arterial puncture sites were to be treated with direct pressure for 10 minutes and until all bleeding had stopped. We found 15 of 31 (48%) patients with pressure dressings had hematomas. However, only 10 of 145 (7%) [$p < 0.001$] arterotomy sites had hematomas when no pressure dressing was used. These findings demonstrate that use of a pressure dressing resulted in an increased likelihood of hematoma. While there are many possible explanations to explain these results, we feel our staff was relying excessively on a pressure bandage to assist hemastatis following arterotomy and not adequately achieving hemostasis prior to applying the pressure dressing. We conclude that reliance on pressure dressings to obtain hemostatis following arterotomy may result in an increased incidence of hematomas.

OF-93-058

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EVALUATION OF A MATHEMATICAL MODEL OF RESPIRATORY MECHANICS

Patrick Benson, MD, Dean Hess, MEd, RRT, Robert M. Kacmarek, PhD, RRT. Massachusetts General Hospital, Boston, MA.

We evaluated a recently published (Am Rev Respir Dis 1993;147:14) mathematical model for respiratory mechanics in a single-compartment mechanical lung model. METHOD: A Puritan-Bennett 7200 delivered constant inspiratory flow to one bellows of a Michigan Instruments adult TTL. Two compliance (C) settings (20-60 mL/cm H_2O) were used. One-way valves segregated inspiratory and expiratory flows to allow independent adjustment of inspiratory (Ri) and expiratory (Rx) resistances. A range of Ri (3.5-35 cm H_2O/L/s) and Rx (15-45 cm H_2O/L/s) were used. Pressures were measured simultaneously at the ventilator Y-piece (*proximal airway pressure*) and in the bellows (*alveolar pressure*) using calibrated Validyne pressure transducers. A Hans-Rudolf screen pneumotachometer was used to measure flow at the Y-piece, and integrated to produce volume. Flow, volume, and pressure were recorded using a computerized system (CODAS). The ventilator was set to deliver various tidal volumes (0.5-1.0 L), rates (10-30/min), and Ti/Ttot (0.17-0.75). A total of 54 combinations of Ri/Rx, C, and ventilator settings were used. Peak inspiratory pressure (PIP), mean airway pressure (MAP), peak alveolar pressure (Ppk), mean alveolar pressure (Pm), and auto-PEEP (Pex) were calculated using the mathematical model and compared to the measured values. The correlation (r) between the measured and predicted values was determined, as well as bias (mean) and precision (SD) between measured and predicted values. RESULTS:

			difference	
	range	r	mean	SD
PIP	12-96	0.997	-2.2	1.9
MAP	3-39	0.997	-1.0	1.9
Ppk	11-57	0.995	-0.9	1.8
Pm	4-32	0.988	-0.1	1.8
Pex	0-24	0.966	-0.8	1.7

CONCLUSIONS: There was a high correlation between the pressures predicted and the actual measured values, and the bias was relatively small. Further work is needed to evaluate this mathematical model in multiple lung unit models, and in mechanically ventilated patients.

OF-93-067

MODIFICATION OF THE FORCED VITAL CAPACITY MANEUVER RESULTS IN LARGER FVCs AND LESS PSEUDORESTRICTION SECONDARY TO OBSTRUCTION

McCarthy K, R-CPT, Laskowski D., R-PFT, Stoller JK, M.D. Cleveland Clinic Foundation Cleveland, OH 44195

In the Modified Spirometry technique, patients are instructed to reduce their expiratory effort when flow falls below 0.2 LPS. This has been shown to enhance patients' ability to achieve ATS end-of-test criteria by prolonging exhalation. We postulated that patients with airways obstruction using the modified technique would significantly increase FVC resulting in fewer patients that would be judged possibly restrictive (FVC <80% of predicted). In a retrospective review of a convenience sample of 48 patients and normals that performed standard and modified spirometry tests in a random fashion, 27 of 48(56%) patients had FVCs < 80% of predicted by the standard technique (71±14%pred). Of these, 7 (22%) had FVCs that increased to ≥80% using the modified technique. The mean FEV1/FVC% of this group was 47±17%. The mean FVC % predicted by the standard technique for this group was 75.8±4.6%. The increase in FVC in this group ranged from 0.13 to 0.92L (mean 0.48±0.28L). Using the modified spirometry technique, the FVC % predicted was 89.3±7.6%. We conclude that in addition to enhancing the ability to meet ATS end-of-test criteria, the modified spirometry technique can result significantly higher FVCs in many patients with airways obstruction. This can result in cost savings afforded by the reduced number of patients needing lung volume determinations to rule out co-existing restrictive and obstructive lung disease. OF-93-099

EVALUATION OF THE PURITAN-BENNETT 3300 INTRA-ARTERIAL BLOOD GAS (IABG) SYSTEM.

Ray Ritz, BA, RRT, Dean Hess, MEd, RRT, Robert Kacmarek, PhD, RRT, William Hurford, MD. Massachusetts General Hospital, Boston, MA.

Continuous monitoring of blood gases and pH with an indwelling sensor is now available. We evaluated the accuracy of the Puritan-Bennett 3300 IABG system, which uses a fluorescent-based intra-arterial sensor to measure PO_2, PCO_2, and pH. METHODS: The study population consisted of 8 critically ill adults (median age 69 yrs, 4 males). A 20-g, 4.5 cm, Becton-Dickinson radial artery catheter was used, and the sensor was passed through the catheter following calibration. The IABG system was used per manufacturer's specifications. A standard blood pressure (BP) monitoring set-up was attached to the Y-port of the sensor for measurement of BP and infusion of flush solution. Vigilant attention to adequate flushing allowed uninterrupted monitoring of BP during IABG sensor use. A NEXT computer continuously recorded data from the IABG monitor, the ventilator (Puritan-Bennett 7200), and the bedside critical care monitor. ABGs were obtained using standard technique as clinically indicated. The IABG value at the time of ABG collection was obtained from the NEXT computer. *In-vitro* ABG analysis was performed using a calibrated Corning 178; appropriate quality control and proficiency testing procedures were followed. Statistical analysis used was Bland and Altman analysis (bias=IABG-Corning), ANOVA to compare biases, and F-ratio to compare variances. RESULTS: Bias ± precision were:

PO_2 (n=160)	1.3±15.3 torr
$PO_2 \geq 100$ (n=63)	-1.1±21.8 torr
$PO_2 < 100$ (n=97)	3.1±8.7 torr
PCO_2 (n=160)	-1.9±5.1 torr
pH (n=157)	0.01±0.05

We used 17 sensors (median 8 comparisons/sensor and median time of sensor use 39.15 hrs). For PO_2, there was a difference in bias between patients and sensors ($P<0.001$ in each case). For PCO_2, there was no significant difference in bias between patients ($P=0.2$), but a significant difference between sensors ($P<0.001$). For pH, there was a significant difference in bias between patients and sensors ($P<0.001$ in each case). There was a significant difference in precision between $PO_2<100$ torr and $PO_2 \geq 100$ torr ($P<0.001$). CONCLUSIONS: We found differences in bias between patients and sensors. However, the overall bias and precision may be acceptable for usual clinical use. For PO_2, the precision was significantly better at $PO_2<100$ torr. Further work is needed to evaluate the cost-effectiveness of this technology and its effects on patient outcome.

OF-93-105

THE EFFECT OF BARRIER FILTERS ON PULMONARY FUNCTION

SNOW MG,RPFT; PRICE KJ,CPFT;
AND FALLAT RJ,MD
CALIFORNIA PACIFIC MEDICAL
CENTER, SAN FRANCISCO

Introduction: Barrier filters are increasingly used to protect patients from cross-contamination. Little objective information has been reported on the effect of the additional resistance and deadspace which the filter adds to the PF circuit. **Methods:**
The Pall filter adds 40 ml of deadspace and less than 0.2 $cmH_2O/L/sec$. Twenty seven subjects underwent complete PF testing with one additional Pall filter in line and sixteen of these patients were also tested with three additional filters to simulate other, larger deadspace filters. Comparisons between variables were made using a paired t test. **Results:** Paired t test showed significant changes with one additional filter only in FEFmax ($p=0.006$). TGV and TLC were significantly different without the deadspace correction ($p=0.034$ and $p=0.039$ respectively) but not after correcting for the additional measured deadspace. With three extra filters (120 ml additional deadspace/0.6 $cmH_2O/L/sec$), significant differences were seen in FEFmax ($p=0.0002$), Raw ($p=0.007$), SRaw ($p=0.0002$), TLC ($p=0.04$), RV/TLC ($p=0.004$) and VA ($p=0.007$). **Conclusions:**
A barrier filter introduces statistically significant, but not clinically meaningful, changes in determination of FEFmax. Other PF variables are unaffected. Larger deadspaces and additional resistance as may be seen with other filters introduced statistically significant changes in several variables which could not be corrected by adjusting for the characteristics of the filters. Barrier filters with larger deadspaces and higher resistances may result in clinically meaningful, significantly different results in pulmonary function tests.

OF-93-118

PFT CHANGES WITH RESTRICTIVE LUNG DISEASE

PRICE KJ, CPFT; SNOW MG, RPFT,
LASMAN TE, MD, FALLAT RJ, MD

Introduction: Most commonly, lung volumes, spirometry and diffusion are used to diagnose and quantify restrictive lung disease (RLD). This approach requires the measurement of total lung capacity (TLC) which may not be available as a screening procedure. Spirometry is almost universally obtained as screening data. Several spirometric variables provide information regarding elastic recoil, which is characteristically elevated in RLD. FVC, FEV1/FVC, IC, FEFmax/FVC and FEF2575%/FVC were evaluated for discriminatory benefits quantifying RLD. **Methods:** Results were extracted from a computer database for 492 male patients with spirometry, lung volumes and single breath diffusing capacity. 193 patients were classified with varying degrees of RLD by a pulmonary specialist. 299 patients were read as normal. Spirometric and lung volume variables were retrospectively correlated with physician determined RLD severity. **Results:** The strongest correlations with RLD severity were FVC(0.82), TLC(0.81), FEV1(0.80), VA(0.79), IC(.72), DLCO(0.70), FEFmax/FVC(0.48), FEF25-75%(0.39), FEFmax(0.37), FEF2575%/FVC(0.36) and FEV1/FVC(0.32). Using common spirometric measurements with the addition of FEFmax/FVC and FEF2575%/FVC ratios provided similar discrimination to that obtained with spirometry and lung volumes. **Conclusions:** The use of FEFmax/FVC and FEF2575/FVC ratios and IC slightly enhances the diagnosis and classification of RLD. However, in the absence of lung volume determinations, spirometric measurements can provide similar degrees of quantification.

OF-93-120

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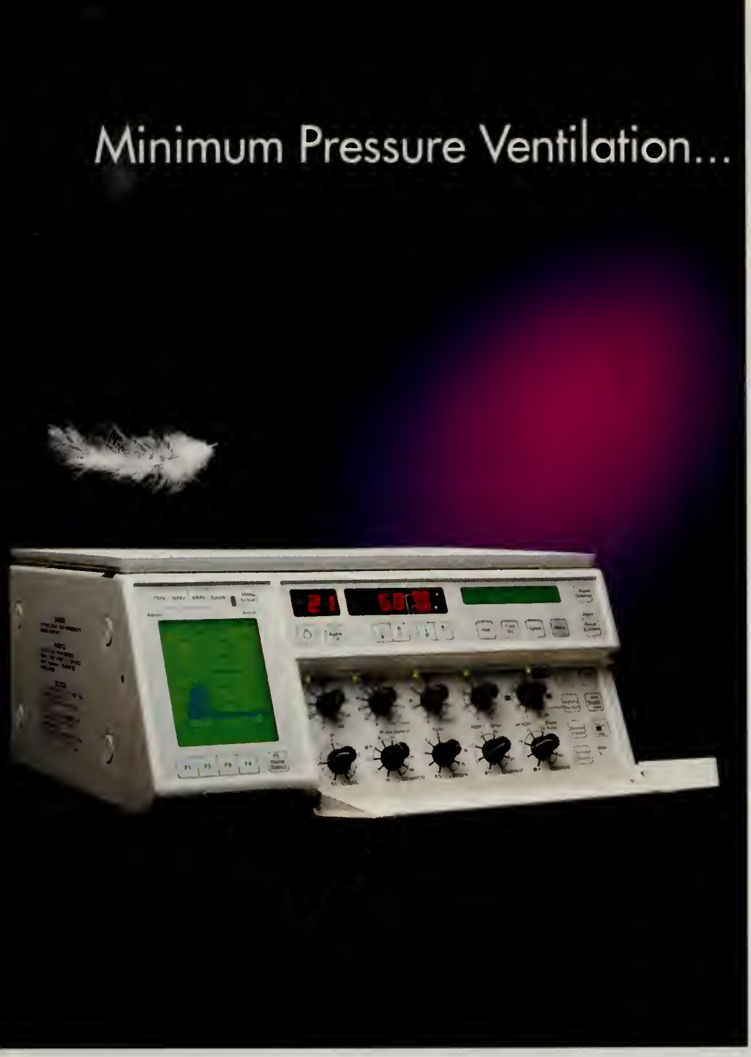

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[1] Cohen, I. et al. 1988 *Endotracheal tube occlusion associated with the use of heat and moisture exchangers in the intensive care unit.* Critical Care Medicine 16,3:277-279.

[2] Sample cost comparisons available on request.

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ANALYSIS OF DIFFERENCES BETWEEN THE TOTAL ENERGY EXPENDITURE AND THE RESTING ENERGY EXPENDITURE

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Introduction: Energy expenditure can be calculated from measurments of oxygen consumption (VO_2). and carbon dioxide production (VCO_2). Either 24 hour total energy expenditure (TEE) or resting energy expenditure (REE) measurements can be obtained. TEE is an average of sleeping, resting and activity data. Whereas the REE by its very name implies that the data was obtained under strictly defined circumstances with the patient awake, not moving, but responsive to surrounding events. We studied the relationships and differences between the TEE and REE in a group of long term postoperative ventilator patients.

Methods: Ten patients were studied for a total of 86 days. A Puritan-Bennett 7250 metabolic monitor was used to measure VO_2 and VCO_2. The 7250 is attached to a 7200 ventilator and is able to measure energy expenditure continuously. We used 24 hour averages to provide TEE data. During 7AM and noon data was printed out in one minute intervals and a running log was kept of patient activities so resting periods could be identified. These resting values were used to calculate REE.

			TEE/REE	Change (%) Day to Day	
	REE	TEE		TEE +15	REE +20
	Kcal/day				
pt #1	1793	1808	0.97	4.8	0.13
4 pt days	(34)	(63)	(0.04)	(3.3)	(3.4)
pt #2	1616	1666	1.0	0.68	-0.1
13 pt days	(124)	(119)	(0.065)	(4.65)	(8.90)
pt #3	2070	2093	0.98	-0.82	-2.29
8 pt days	(209)	(134)	(.04)	(3.1)	(7.5)
pt #4	1325	1387	1.00	0.33	0.33
13 pt days	(165)	(183)	(0.07)	(11.9)	(12.3)
pt #5	2208	2135.6	0.97	3.5	1.4
6 pt days	(30.3)	(395)	(0.04)	(5.3)	(4.06)
pt #6	2268	2279.5	1.01	0.29	0.20
6 pt days	(60)	(100)	(.04)	(4.5)	(1.5)
pt #7	3041.6	2720	0.89	0.14	0.18
20 pt days	(49.3)	(36.5)	(0.01)	(2.5)	(2.8)
pt #8	1893.9	1771.8	0.96	2.2	0.7
6 pt days	(68)	(59.8)	(0.06)	(3.9)	(7.7)
Average	2004	1972	0.97	1.23	0.03
SD	(486)	(388)	(0.04)	(1.9)	(1.0)

In long term postoperative ventilator patients there was little difference between REE and TEE. This was also true when calorie requirements ([TEE+15%) / [REE +20%]) were compared. This likely reflects the sedated state of these patients. It also demonstrates that either REE +20% or TEE+15% may be used to determine caloric requirements. In more actively weaning and less ill patients, TEE has been shown to be 5-10% greater than REE.

OF-93-124

COMPUTERIZED DIFFERENTIAL FLOW SYSTEM FOR USE WITH THE SERVO 300^{TM} VENTILATOR

-A.Torres, Jr., M.D., M.Anders, B.S.,R.R.T., S.Wilson, M.S., Arkansas Children's Hospital, Little Rock AR, M.P. Yeh, Ph.D., Consentius Technologies, Sandy UT.

Bias flow ventilation(BSV) presents a challenge for accurate indirect calorimetry measurements. **Hypothesis:** Differential flow measurements with a computerized dual-pneumotach (CDP) system are as accurate as a single pneumotach (SP) during BSV. **Methods:** A Servo 300^{TM} ventilator (SV 300) with inherent BSV was used to ventilate a test lung while volume measurements made by a CDP system were simultaneously compared to a SP system. Inspiratory (insp.) and expiratory (exp.) volumes were compared in both room air and humidified air to determine the effect of humidity on volume measurements. Three sizes of pneumotachs were tested at 3 tidal volumes(V_t) and 2 ventilator rates(f): 0-160 LPM pneumotach with 500,750,and 1000 ml V_t and f of 15 and 30; 0-35 LPM pneumotach with 100,200,and 300 ml V_t, f of 20 and 40; 0-10 LPM pneumotach with 25,50,and 75 ml V_t and f of 30 and 60. **Results:** In the room air studies, mean errors for insp. V_t were within 2.5% and exp. Vt were within 1.8% for all size pneumotachs. In the humidified studies, mean errors were within 1.8% and 2.8% for insp. V_t and exp. V_t for all size pneumotachs. **Conclusion:** Differential flow measurements with a CDP system are as accurate as a SP during BSV with the SV 300.

OF-93-144

RELATIVE ACCURACY OF RAMAN AND MASS SPECTROMETRY FOR MEASURING END-TIDAL CARBON DIOXIDE.

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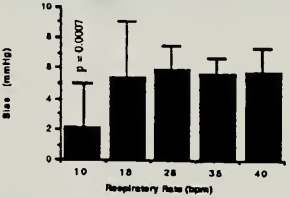
Measurement of respiratory gases, especially carbon dioxide has become the standard of practice for intra-operative monitoring, and is gaining increasing use in the Intensive Care Unit. Several technologies exist which allow these measurements, including infrared, mass spectrometry (MS) and raman spectrometry (RS). Of these both MS and RS measure anesthetic as well as respiratory gases simultaneously. Both MS and RS are gas withdrawal systems, although each has different set gas withdrawal rates. We determined to measure the relative accuracy of these two devices as a function of respiratory frequency (f). A bench-top system was designed to simulate normal respiration, in which the exhaled carbon dioxide (varied from 23 to 85 mmHg), tidal volume (700 ml), and f (set at 10, 18, 28, 35, and 40 bpm) could be controlled. An airway connector with multiple parallel gas sampling ports was designed to allow simultaneous gas sampling from both MS and RS. Sampling catheters from calibrated MS (Perkin-Elmer MGA 1100) and RS (Rascal II Ohmeda Monitoring) were attached to two of these ports. End-tidal carbon dioxide (PetCO2) was collected simultaneously from MS and RS using a data acquisition system. Data was collected in triplicate at each of the 5 f's. Data was analyzed by paired t-test and ANOVA, with $p < 0.05$ considered significant. The bias and limits of agreement were calculated at each of the 5 f's. A total of 60 PetCO2 pairs were collected. RS was consistently higher than MS, $p = 0.001$. The bias and limits of agreement was 5.0 ± 2.7 mmHg for the full range of PetCO2's tested. At $f = 10$ the bias (2.0 ± 2.9) was significantly lower $p = 0.0007$, than at any other frequency (see figure). A small but statistically significant bias exists between MS and RS. For f's greater than 10 this bias is constant. These differences may be due to differences in gas sampling rates, differences in the algorithm for determining PetCO2, as well as differences in the basic measurement technology. This small, but constant, bias should not effect the use of either of these devices in the clinical setting.



OF-93-154

OXYGRAM ANALYSIS FOR VENOUS AIR EMBOLISM DETECTION: A NEW CLINICAL APPLICATION FOR THE INSPIRED TO EXPIRED OXYGEN DIFFERENCE

G B Russell, MD, J.M. Graybeal, CRTT. Department of Anesthesiology, P.S.U., College of Medicine, Hershey, Pennsylvania.

Analysis of the inspired and expired oxygen waveform (oxygram) has been evaluated as a clinical monitor of ventilatory adequacy and the inspired to end-tidal oxygen difference [$F_{(i-e)O_2}$] has been found to increase with hypoventilation. Based on this finding, increases in expired oxygen should occur with the increased dead space seen after venous air embolism (VAE). VAE detection by respiratory gas analysis has concentrated upon increased end-tidal nitrogen and decreased end-tidal carbon dioxide (P_{etCO_2}). We hypothesized that increases in F_{eO_2} and decreased $F_{(i-e)O_2}$, in contrast to other oxygenation indices, would be a sensitive monitor for VAE detection. After institutional approval, 6 mongrel dogs (17-26 kg) were anesthetized with pentobarbital, paralyzed with pancuronium, and mechanically ventilated with 100% O_2 to maintain normocapnea. Each dog was monitored by a femoral artery U440 fiberoptic catheter for intra-arterial oxygen saturation and an Oximetrix P7110 pulmonary artery (PA) catheter for mixed venous oxygen saturation ($S_{\bar{v}O_2}$). Inspired and expired oxygen and P_{etCO_2} were measured by a Rascal II Raman Spectrometer (Ohmeda, Inc). Each dog was embolized by air infused centrally at $0.10\ mL \cdot kg \cdot min^{-1}$ for 20 min (total of $2\ mL \cdot kg^{-1}$) or $2\ mL \cdot kg^{-1}$ given as a bolus. Arterial and mixed venous blood gases were sampled prior to and at 2.5, 5, 10, 20, and 40 min after VAE was begun and measured by a Corning 168 pH/Blood Gas Analyzer and Radiometer OSM2 Hemoximeter. Data were analyzed by ANOVA and regression analysis. A $p < 0.05$ was significant. Expired oxygen increased and $F_{(i-e)O_2}$ decreased with each embolus. With infusions, maximum $F_{(i-e)O_2}$ decreases were 1.72±0.19% at 16.9±5.9 min, returning to baseline in 40±5.9 min. After boluses, $F_{(i-e)O_2}$ decreased a similar amount, 2±4 %, but more rapidly (at 1.4±0.1 min, $p=0.01$), and required the same time (36.6±7 min) to return to baseline. Other interval measurements of oxygenation did not change. There was no correlation of $F_{(i-e)O_2}$ with S_{aO_2}, $S_{\bar{v}O_2}$, P_{aO_2}, or $P_{\bar{v}O_2}$. The P_{aCO_2} trended upward and P_{etCO_2} decreased with boluses (14.1±2.2 mm Hg, $p=0.03$) and infusions (19.3±2.9, $p<0.05$). There was a negative correlation between $F_{(i-e)O_2}$ and $P_{(a-et)CO_2}$ ($p=0.003$, slope 0.036, $r^2=0.285$). Oxygram analysis reliably detects venous air infusions and boluses in this canine model. The correlation with the $P_{(a-et)CO_2}$ suggests that deadspace changes affect the expired oxygen fraction. For further clarification of its full clinical utility, sensitivity and specificity studies will be assessed.

OF-93-156

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EFFECT OF TUBING COMPRESSIBLE VOLUME ON V_D/V_T MEASUREMENTS MADE BY A METABOLIC CART—Keith J. Matters, RRT, Michael S. Benson, BS, RRT, David J. Pierson, MD. Harborview Medical Center, Seattle, Washington.

Measurement of dead space to tidal volume ratio (V_D/V_T) is clinically useful in assessing patient physiological status during mechanical ventilation. In addition to values of $\dot{V}_{CO_2}$ and $\dot{V}_{O_2}$ measured by the Cybermedic Metascope (Cybermedic, Inc.), a V_D/V_T can also be obtained. This V_D/V_T is calculated using the cart F_{eCO_2} and patient's P_{aCO_2} in the standard V_D/V_T formula. This V_D/V_T value may be affected by tubing compressible volume (TCV) dilution during mechanical ventilation. In order to determine the effect of TCV on the accuracy of V_D/V_T reported by the metascope we compared the metascope V_D/V_T to a standard V_D/V_T measurement by Douglas Bag technique (eliminating TCV) in 22 mechanically ventilated adult patients. All patients were ventilated with Siemens Servo 900C ventilators in the AMV or SIMV mode. F_{IO_2}s ranged from 0.30 to 0.70 with 17 patients receiving PEEP from 5 to 20 cm H_2O. Minute ventilation ranged from 9 to 23 L/min. Ten patients were ventilated with standard tubing (TCV factor of 3 mL cm H_2O) and 12 patients had a low compressible volume circuit (TCV factor 1 mL cm H_2O). The order of V_D/V_T measurement was randomized with a pause of 10 minutes between measurements. The same P_{aCO_2} was used for both V_D/V_T calculations. Mixed expired gas collection from the 900C (eliminating TCV) was accomplished using a previously described method (Respir Care 1986;31:1096-1098). Values were analyzed using paired t test and $p<0.05$ was considered significant. Results: Metascope V_D/V_T measurements in all patients ranged from 47% to 87% (mean = 62%) compared to Douglas bag V_D/V_T which ranged from 33% to 86% (mean = 56%). The V_D/V_T values reported by the metascope (N=22) were significantly higher than V_D/V_T values calculated using Douglas bag technique ($p<0.001$). Mean error by metascope in all patients was 6.2% (range = −1.0 to +15.0%). Mean error in the low TCV factor group (N=12) was 4.4% (range = −1.0 to +10.0%) compared to standard tubing (n=10), with a mean error of 8.5% (range = +3.0% to +15%). Conclusions: Based on these results we conclude that TCV causes overestimation of V_D/V_T when determined using the Cybermedic Metascope. Error varies according to TCV factor, peak airway pressure, and rate of mechanical ventilation, and can be as large as 15%. V_D/V_T determination using the Cybermedic Metascope should be corrected for TCV dilution as previously described (Respir Care 1979;24: 435).

OF-93-215

AARC ANNUAL MEETING HIGHLIGHTS
Special Research Seminar

Presented by the Editorial Board of
RESPIRATORY CARE 9:00-11:30 am
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Robert L Chatburn RRT, Cleveland OH/*Chairing*

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Objectives: At the conclusion of this seminar, the participant will be able to

- describe types of research RCPs should do: equipment evaluations, case reviews, descriptive/correlative/inferential studies;
- present ideas from everyday clinical issues that RCPs should use to recognize potential research problems. Also, how to refine an idea into a problem statement: identifying a theoretical framework, creating hypotheses, and identifying possible confounding factors;
- describe how to set up experiments that will test the hypothesis, as well as the intricacies of doing a feasibility analysis to decide whether or not one can do the study;
- explain how to use bibliographies from review papers, how to do database searches, and how to identify what is quotable and what is not (or don't believe everything you read!);
- detail the agonies of "working without pay" when doing clinical research, and how to obtain funding from the department, the hospital, or outside sources.
- understand the importance of statistics in clinical research: simple sample sizes, titillating and terrifying tests, and how to avoid dangerous territories;
- present the proper way for preparing and presenting abstracts, posters, and manuscripts of the work done, as well as the ins and outs of journal requirements and review processes.

9:00 am	**Research as Part of the Job: Why Should I Do Research?** James K Stoller MD, The Cleveland Clinic Foundation, Cleveland OH
9:30 am	**Searching the Literature: Has This Been Done Before?** Dean R Hess MEd RRT, Massachusetts General Hospital, Boston MA
10:00 am	**Funding without Funds** David J Pierson MD, Harborview Medical Center, Seattle WA
10:30 am	**Statistics for the Uninterested** Joseph L Rau PhD RRT, Georgia State University, Atlanta GA
11:00 am	**Communicating the Research Results** Robert L Chatburn RRT, Rainbow Babies and Childrens Hospital, Cleveland OH

TRANSPORT UNIT FOR ARDS PATIENTS REQUIRING UNINTERRUPTED VENTILATION

Steve Tunnell RRT, Cliff Wright, David Willms MD, Misty Parrish RRT, Margaret Nield PhD. Sharp Memorial Hospital, San Diego, California

INTRODUCTION: We report on the development of a unit for intrahospital transport of severe ARDS patients who require uninterrupted ventilation and alternate ventilatory modes. **METHOD:** A gurney was modified and mounted with a Siemens 900C ventilator, uninterruptable electrical power supply, 4 E-cylinders of O_2, an oximeter and cardiac monitor. The O_2 source attached directly to the 900C gas inlet, mandating FiO_2 1.0. Bench analysis was done utilizing a VT-101 test lung with compliance set at 0.02 L/cmH_2O. Ventilator settings were: pressure control 50 cmH_2O, PEEP 10 cmH_2O, I:E ratio 1:1, and respiratory rate 30 bpm. During actual patient use we prospectively collected data on duration of transport, ventilator settings, ABGs, and complications during transport. Prolonged transport times could be achieved by utilizing wall electrical and O_2 supplies at transport destinations, without interrupting ventilation. **RESULTS:** Bench test operating time was 80 min. Clinical use was 14 transports in 9 ARDS patients. Eleven transports used pressure control, 7 inverse ratio, and 3 ECMO plus ventilator support. Mean parameters were: RR 25, peak airway pressure 40 cmH_2O, PEEP 7 cmH_2O, FiO_2 .83, PO_2 78 torr, PCO_2 47 torr. Mean duration of transport was 66 min (range 15-105 min). Complications were CVP line dislodgement(n=1), and O_2 disconnection from the ventilator (n=2). No patient experienced clinically significant O_2 desaturation, airway dislodgement, hypoventilation, or hemodynamic instability. Patients could be placed on a CT scanner or x-ray table without disconnection from the unit. Prior to use of the transport unit, 6-8 staff were required to transport patients with severe ARDS. We transport now with 3 staff (1 RRT) **CONCLUSION:** A simple self-contained unit can be devised to deliver alternate modes of ventilation to severely ill ARDS patients, permitting safe and uninterrupted ventilation during intrahospital transport.

OF-93-018

EVALUATION OF FDO_2 FROM DISPOSABLE RESUSCITATORS.

Chantal Marquis-D'Amico, BS, RRT, Joe Kratohvil, RRT, Dean Hess, MEd, RRT. Massachusetts General Hospital, Boston, MA.

Manual resuscitators are often judged by their ability to deliver a high FDO_2. The ASTM standard is $FDO_2 > 0.85$. We conducted this study to evaluate FDO_2 from adult disposable resuscitators. METHODS: We evaluated the following disposable resuscitator brands: Ambu, Artec, Pulmonex, Hospitak, Hospitak Bauman, Intertech, LSP, Mercury, Puritan Bennett, Respironics, Vital Signs (Code Blue I and II). For those resuscitators with tube and bag style reservoirs, FDO_2 was determined in both configurations; 21 different configurations were evaluated. A calibrated Hudson Ventronics O_2 Analyzer was used to determine FDO_2. An O_2 flow of 15 L/min to the resuscitators was used throughout. The analyzer cell was placed between the resuscitator and a Michigan Instruments TTL (compliance 0.05 L/cm H_2O and resistance 5 cm H_2O/L/s), and the TTL was ventilated until a stable FDO_2 was produced. An operator familiar with the technique of bag-valve ventilation manually ventilated the TTL using 2 ventilatory patterns for each device: rate of 12/min and V_T of 0.6 L, rate of 20/min and V_T of 1 L. To evaluate FDO_2 with simulated spontaneous breathing from the resuscitators, one side of the TTL was attached to a Puritan Bennett 7200 and a lift bar was used to lift the other lung. The resuscitator was attached to the *spontaneously* breathing lung. The following spontaneous breathing patterns were evaluated: rate 20/min, V_T 0.5 L, decelerating flow 45 L/min; rate 30/min, V_T 0.8 L, flow 90 L/min. Three of each or the 21 resuscitator configurations was evaluated for each set of conditions with operator controlled ventilation and with spontaneous breathing. RESULTS: For operator controlled ventilation, there was a significant difference in FDO_2 between resuscitators for both ventilatory patterns ($P < 0.001$ by ANOVA). At the lower ventilation, FDO_2 was > 0.85 for all resuscitators. At the higher ventilation, only the Intertech with tube reservoir was able to deliver $FDO_2 > 0.85$. For spontaneous ventilation, there was also a significant difference in FDO_2 between resuscitators for both ventilatory patterns ($P < 0.001$ by ANOVA). At the lower ventilatory pattern, all resuscitators except the Vital Signs delivered $FDO_2 > 0.85$. At the higher spontaneous ventilatory pattern, only 11/21 resuscitators were able to deliver $FDO_2 > 0.85$. Although there were significant differences in FDO_2 between tube and bag style reservoirs ($P < 0.001$), these differences were too small to be considered clinically important. CONCLUSIONS: With disposable resuscitators, FDO_2 is affected by resuscitator design and the level of ventilation for both operator controlled and spontaneous ventilation. Some resuscitators are unable to deliver high FDO_2 at higher levels of ventilation.

OF-93-061

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COMPLIANCE AND RECOIL TIME FOR DISPOSABLE RESUSCITATORS.

Joseph Kratohvil, RRT, Dean Hess, MEd, RRT.
Massachusetts General Hospital, Boston, MA.

We evaluated the compliance of the bag material and recoil time for disposable resuscitators. METHODS: A rigid airtight noncompliant box was constructed to allow a resuscitator to fit inside and the patient valve to vent to the outside. The tube reservoir of the resuscitator was fitted to the outside. The resuscitator was compressed by pressurization of the box interior with a Puritan-Bennett 7200 ventilator. The ventilator was set at 10/min and a flow of 60 L/min. Pressure in the box was measured with a Validyne transducer. Flow leaving the resuscitator (to the outside of the box) was measured with a Hans-Rudolf screen pneumotachometer, and integrated to volume; the ventilator was set such that a volume ~0.8 L was delivered from the resuscitator. A pneumotachometer was also fitted to the gas inlet tube of the resuscitator; bag recoil time was measured from this flow signal. Pressure and flow were recorded on a computerized CODAS system. Compliance was calculated as volume leaving the resuscitator divided by box pressure. The following resuscitator brands were evaluated: Ambu, Artec, Pulmonex, Hospitak, Intertech, LSP, Mercury, Puritan Bennett, Respironics, Vital Signs (Code Blue I and II). Due to its unique design, recoil could not be evaluated for the Respironics. Three of each brand were evaluated, and compliance and recoil were determined for five breaths each. Statistical analysis consisted of mean±SD and ANOVA. RESULTS:

	compliance (mL/cm H_2O)	recoil (s)
Ambu	66.6±6.0	1.5±0.08
Artec	43.8±2.2	0.9±0.1
Pulmonex	42.1±0.5	1.0±0.2
Hospitak	36.9±1.8	0.9±0.1
Intertech	42.5±2.1	1.0±0.1
LSP	29.9±0.6	0.9±0.1
Mercury	40.3±3.4	0.8±0.2
Puritan Bennett	61.4±2.3	1.3±0.2
Respironics	41.5±2.7	-----
Code Blue I	57.5±6.2	1.5±0.3
Code Blue II	53.2±2.0	1.2±0.2

There were significant differences between resuscitators for compliance (P<0.001) and recoil (P<0.001). CONCLUSIONS: We found significant differences in compliance and recoil for the resuscitators evaluated in this study. A resuscitator with a high compliance may produce less fatigue, and one with a shorter recoil may allow more rapid ventilation rates. Further work is needed to evaluate the clinical importance of this.

OF-93-066

IMPOSED WORK DURING SPONTANEOUS BREATHING WITH ADULT DISPOSABLE RESUSCITATORS.

Christopher Hirsch, MPH, RRT, Sylvester Barker, Joseph Kratohvil, RRT, Dean Hess, MEd, RRT, Robert Kacmarek, PhD, RRT.
Massachusetts General Hospital, Boston, MA.

Although resuscitators are usually used to provide manual ventilation, they are occasionally used with patients who are spontaneously breathing. We conducted this study to evaluate the imposed work of spontaneous breathing with disposable resuscitators. METHODS: A Puritan-Bennett 7200 was attached to one side of a Michigan Instruments TTL, and used to lift the contralateral lung to simulate spontaneous breathing. A rate of 20/min and decelerating flow pattern were used. The following ventilatory patterns were used: V_T 0.25 L, flow 40 L/min; V_T 0.5 L, flow 80 L/min; V_T 0.8 L, flow 120 L/min. Pressure was measured with a Validyne MP45-32-871. Flow was measured with a Hans-Rudolf 4700 pneumotachometer and Validyne MP45-14-871 transducer with a Hewlett-Packard 7758B integrater. CODAS was used to integrate the volume-pressure loops for inspiratory and expiratory imposed work in joules/L (J/L). The following resuscitators were evaluated: Ambu, Artec, Pulmonex, Hospitak, Intertech, LSP, Mercury, Puritan-Bennett, Respironics, Vital Signs. Three of each brand were evaluated, and W/L was determined for 5 breaths. Two of the resuscitators (Respironics and Hospitak) are available with integral PEEP valves; the inspiratory work at 0 and 10 cm H_2O PEEP was determined for these devices. Statistical analysis consisted of mean ±SD and ANOVA. RESULTS:

	inspiratory work (J/L)	expiratory work (J/L)
V_T 0.25 L, flow 40 L/min	0.21±0.11	0.18±0.05
V_T 0.5 L, flow 80 L/min	0.44±0.12	0.29±0.05
V_T 0.8 L, flow 120 L/min	0.73±0.13	0.40±0.07

There were significant differences in work between inspiration and expiration (P<0.001), and between the 3 ventilatory patterns. For each ventilatory pattern, there was a significant difference in work among resuscitators for both inspiration and expiration (P<0.001 in each case). The inspiratory work with PEEP was very high for both the Respironics and Hospitak (1-2 J/L). CONCLUSIONS: The imposed work of breathing through the valves of disposable resuscitators is high enough to be considered clinically important, particularly with high ventilatory demand and PEEP. The imposed inspiratory work may produce respiratory muscle fatigue. The expiratory work may prolong exhalation and produce auto-PEEP. For this reason, it may not be good practice to allow patients to breathe spontaneously from these devices.

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TIDAL VOLUME DELIVERY FROM DISPOSABLE RESUSCITATORS.

Dean Hess, MEd, RRT, Sylvester Barker, Joseph Kratohvil, RRT. Massachusetts General Hospital, Boston, MA.

We evaluated the volume delivery of adult disposable bag-valve resuscitators. METHODS: The following resuscitators were evaluated: Ambu, Artec, Pulmonex, Hospitak, Intertech, LSP, Mercury, Puritan Bennett, Respironics, Vital Signs (Code Blue I and II). Ventilation was delivered to Michigan Instruments TTL (compliance 20 mL/cm H_2O, resistance 20 cm H_2O/L/s) at a rate of 12/min. Each resuscitator was evaluated using 1 and 2 hands to squeeze the bag. Flow from the resuscitator was measured using a calibrated Hans-Rudolf pneumotachometer, integrated to volume, and recorded on a computerized CODAS system. V_T was averaged for 5 breaths during the first minute of ventilation. The order in which the bags were evaluated, and 1 versus 2 hands, were randomized. At least 10 min were allowed between data collection sessions to minimize fatigue. All ventilation was provided by the same individual, with a hand size consistent with ASTM Standard F 920. Statistical analysis consisted of mean±SD and ANOVA. RESULTS:

	1 hand volume	2 hand volume
Ambu	613±16	807±50
Artec	625±24	844±19
Pulmonex	595±23	800±52
Hospitak	448±30	549±19
Intertech	637±24	843±25
LSP	644±62	788±30
Mercury	626±17	789±37
Puritan-Bennett	589±23	674±33
Respironics	589±22	712±38
Code Blue I	647±28	881±35
Code Blue II	704±52	823±34

There was a significant difference between resuscitator brands ($P<0.001$) and the number of hands used to squeeze the bags ($P<0.001$). CONCLUSIONS: There was a significant, and in some cases clinically important, difference in volume delivery between resuscitators. Some, but not all, met the ASTM standard of 0.6 L with 1 hand ventilation; all but one delivered >0.6 L with 2 hands. During 1 hand ventilation, none met the Heart Association standard of 0.8 L, but 6 met that standard during 2 hand ventilation. These results are consistent with previous resuscitator evaluations, emphasizing the differences between resuscitator brands and the importance of using 2 hands to squeeze the bag.

OF-93-069

A COMPARISON OF TIDAL VOLUME AND PEAK FLOW IN THE PRESSURE CONTROL MODE BETWEEN THE PURITAN BENNETT 7200AE AND HAMILTON VEOLAR.

William T Clark AS, RRT. Daniel J Reily BS, RRT. University of Pennsylvania Medical Center, Philadelphia, Pennsylvania.
Louis N Harris EdD, RRT. Youngstown State University. Youngstown, Ohio.

With the advent of the microprocessor controlled mechanical ventilator, pressure control ventilation(PCV) is undergoing a resurgence. As volume ventilator capabilities among different brands vary, tidal volume(VT) and peak flow(PF) capabilities may vary among brands of ventilators in PCV mode. This study was undertaken to determine if VT delivery and PF varied significantly between a Purtian-Bennett(PB) 7200ae and Hamiltion Veolar ventilator. A Biotek VT-1 ventilator tester was used to simulate various patient lung conditions. A BiCore CP-100 respiratory monitor with flow transducer was used to measure inspired VT, PF, respiratory rate(RR), I:E ratio and peak airway pressure at the patient wye. An identical PB silicone circuit was used on both ventilators. The humidification system was bypassed. A total extended self test was performed and passed on a recently calibrated 7200ae. The Veolar was flow calibrated and leak tested per manufacturers specifications. Inspiratory pressures of 20, 30, 40, and 50 cm H20 were used with each ventilator. RR was kept constant at 10 breaths/minute. I:E ratios selected for testing were 1:1, 1:2, 1:3, and 1:4. Compliance(C, L/cm H20) and resistance(Raw, cm H20/L/sec) combinations were selected as follows (C/Raw) 0.01/5, 0.02/5, 0.05/5, 0.01/20, 0.02/20, 0.05/20, 0.01/50, 0.02/50, and 0.05/50. All pressures, PF, VT, and I:E ratios were recorded and verified by the CP-100. Five values for VT and PF at each setting were averaged. A independent student's t-test was used to evaluate the paired data with significance set at $p<0.05$(n=144). For the 7200ae, mean VT was 0.76L(SD.51). The Veolar mean VT was 0.73L(SD .51). The 7200ae mean PF was 0.96 L/sec(SD .42). The Veolar mean PF was 0.91 L/sec(SD .41). The t-test showed no significant difference in performance between these two ventilators in PCV mode using a lung simulator with conventional ratio ventilation with regard to PF and VT.

OF-93-077

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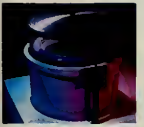

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BENCH AND CLINICAL EVALUATION OF THE PROTOTYPE BIRD 1000PV TRANSPORT VENTILATOR.

Tom Malinowski, BS,RRT,RCP, Patrick Moore MBA,RRT,RCP,Michael Lum, BS,RRT,RCP, Michael Terry, RRT,RCP Department of Respiratory Care, Loma Linda University Medical Center, Loma Linda, CA 92354

Introduction: Portable transport ventilators can provide safe and efficient mechanical ventilation. We report a laboratory and clinical evaluation of the Bird 1000PV Transport ventilator (PV). PV can provide both volume and time-cycled pressure limited ventilation. **Methods:** Using a single compartment test lung model (BIOTEK VT-1) with a pressure pneumotach(VENTRAK) inline, we evaluated the reproducibility of 10 consecutive tidal volumes at.2L, .5L, and 1.0L) at multiple compliances (.1,.05,.02L/cm H_20) and resistors(MII,pneuflo resistor,RP 5.6, 7.7 mm I.D). CLINICAL EVALUATION Thirty six (36) MV patients requiring transport were placed on PV at ventilator settings equivalent to the ICU settings (exception: PV - Assist/ Control mode, FIO_2 1.0 only). We compared pre and during VT and VE in the clinical group. **Results:** Mean values (SD)

Delivered VT at Varying Compliances - Resistor = 7.7

set VT	.1 L/cm H20	.05 L/cm H20	.02 L/cm H20
200 ml	161 (1.3)	158.6 (1.5)	155.5 (1.8)
500 ml	493 (1.2)	482.5 (6.4)	463.3 (1.5)
1000 ml	1022.4 (2.2)	1006 .6 (3.6)	921 .4 (2.0)

Delivered VT at Varying Compliances - Resistor = 5.6

set Vt	.1 L/cm H20	.05 L/cm H20	.02 L/cm H20
200 ml	175.8 (1.9)	168.1 (.95)	159.2 (1.1)
500 ml	492.0 (1.9)	485.7 (1.6)	464.4 (1.3)
1000 ml	875.1 (2.2)	1001.9 (1.9)	875.3 (2.2)

Clinical Evaluation

	Before	During	
VT (L)	.800 (.110)	.800 (.100)	ns
VE (L)	12.02 (4.44)	14.01 (3.46)	p <.025

Conclusions: A slight reduction in all ranges of delivered VT occurred when compliance was reduced from .1 to .02L. This occurred with both resistors. The exception was 1000 ml at 5.6. A reduction in Resistor size (7.7 to 5.6) further reduced the 1000 ml VT. Clinical evaluation demonstrated no significant difference in VT settings. Differences in VE can be attributed to placement on assist/control mode of ventilation vs. IMV. The PV can provide clinically acceptable VT under normal and low compliance conditions.

OF-93-133

EFFECT OF AIRWAY RESISTANCE ON VOLUME DELIVERY USING PRESSURE LIMITED VS. VOLUME LIMITED MODES OF VENTILATION.

J.M. Graybeal, CRTT, P.E. Frishkorn, RRT, G.B. Russell, MD. Depts. Anes. and Resp. Care, Penn State U., College of Medicine, Hershey, Pa. 17033

Several conditions such as asthma, ARDS, and peripheral airway edema, are associated with an increase in airway resistance (Raw). We determined to measure the effect of increasing Raw on the delivered tidal volume (Vt); comparing the difference between volume and pressure limited (VL and PL respectively) modes of ventilation. Using a test lung (Medishield Lung Simulator) and a calibrated pneumotachometer system (Sensormedics 2600, Sensormedics, Inc.) we measured the effect of increasing Raw, from 0, 5, 20, 50, 200 cmH2O/L/sec, on both the VL and PL modes of ventilation from a Siemens Servo 900C and a Hamilton Veolar. The ventilators were both set as follows; Vt = 900 ml., RR = 10 bpm, FiO2 = 0.50, I:E = 1:2. Vt was measured at the connection to the lung simulator. All measurements were made in triplicate and are expressed as mean (± SD). Measurements were repeated under conditions of normal compliance (Fig 1) as well as low compliance (10 ml/cmH2O) (Fig 2).During normal compliance Vt Δ's increased fro each increase in Raw. While at low compliance the was a minimal effect on ΔVt until Raw reached 200cmH2O/L/sec. The information suggests that in disease states which have a combined low compliance and high Raw such as ARDS, Δ's in Raw may have no significant effect on deliverred Vt. This does not appear to be the case in situations with high Raw only such as asthma or airway edema from smoke inhalation.

Fig1 Δ in Vt (increasing Raw and normal compliance)

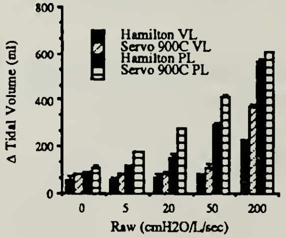
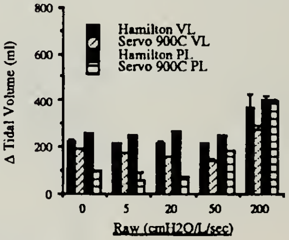


Fig 2 Δ in Vt (increasing Raw and low compliance)



OF-93-157

COMPARISON OF MINUTE VENTILATION DELIVERED BY CLINICIANS USING MOUTH-MASK MANUAL RESUSCITATION, ONE-HANDED BAG-VALVE-MASK VENTILATION & TWO-HANDED BAG-VALVE-MASK VENTILATION AS THESE TECHNIQUES WERE PERFORMED ON A RESUSCI-ANNIE MODEL.

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There are three commonly used techniques to manually ventilate patients without an artificial airway: Two-handed bag-valve-mask ventilation (2-H B-V-M), one-handed bag-valve-mask ventilation (1-H B-V-M), and mouth-mask ventilation (M-M). The purpose of this study is to compare the minute ventilation delivered from these three techniques as they are currently performed by nurses, respiratory therapists and respiratory technicians in an acute care hospital setting. $N=40$ (18 staff respiratory therapists and technicians, 12 RN's from a pulmonary medical unit, 10 RN's from a medical-surgical ICU). On a "Recording Resusci-Annie" doll (Laerdal Manufacturing, Inc) participants performed two one minute trials of each, 1-H B-V-M (using one individual), 2-H B-V-M (using two individuals: the participant using 2 hands to affect a seal, a researcher providing a consistant bag compression), and M-M (using one individual). During each trial, the volume of air delivered from the bag and the volume of air received by the doll were measured by spirometers in line between the bag and mask and between Anne and her exhalation vent respectively. Observations were noted regarding mask placement on the face for obvious leaks, and recording strip to ensure full exhalation between each breath delivered. Eight nurses failed to open the airway effectively delivering no volume to the doll. Of the remaining 32 participants, minute ventilation delivered in liters ranged [2.7 - 12.7 (1-H B-V-M)], [3.2 - 12.9 (2-H B-V-M)], [2.0 - 17.6 (M-M)]. There was no significant differences found between the volumes delivered by nursing vs. respiratory staff (Student's unpaired t-test, $p < 0.05$), or between the three techniques used (repeated measures ANOVA, $p < 0.05$). In conclusion, it is essential that techniques in the successful use of specific manual resuscitators be included in annual recertification programs. Further study is needed to evaluate specific variables which contribute to successful manual resuscitation.OF-93-019

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EXPIRATORY RESISTANCE IMPOSED ON A MANUAL RESUSCITATOR BY OPTIONAL PEEP VALVE AND EXHALATION FILTER.

Thomas A Barnes, EdD, RRT, Northeastern University, Boston, MA. I evaluated the expiratory resistance (R_E) of the Intertech/Inspiron 1st Response adult manual resuscitator P/N 008003 (1st Response) without and with Intertech/Inspiron PEEP valve P/N 008001 (PEEP valve) and exhalation valve filter P/N 008018 (Filter). **Method:** the R_E of the 1st Response with and without Filter and PEEP valve was evaluated against the Standard 8382:1988 specified by the International Organization for Standardization (ISO), i.e., expiratory pressure (P_E) $\le$ 5 cm H_2O without PEEP devices attached with air introduced to the patient connection port at a flow of 50 L/min. The pressure generated at the patient connection port was measured using a Timeter RT-200 Calibration Analyzer (RT-200). The air flow into the patient connection was verified using the RT-200. Five samples of the 1st response, PEEP valve, and Filter were evaluated with PEEP valve set at 5, 10, 15, and 20 cm H_2O. Filter and PEEP valve were randomly assigned to each 1st response sample and tested as a set. The ISO test method for R_E was used with P_E measured at the patient connection for nine configurations of PEEP valve and Filter. **Results:**

P_E at the Patient Connection Port†

PEEP (cm H_2O)	No Filter (cm H_2O)	Filter (cm H_2O)
0	4.21 (0.33)	5.82 (0.24)
5	14.44 (0.86)	16.74 (0.78)
10	19.61 (0.99)	21.28 (0.79)
15	24.22 (0.78)	26.04 (1.02)
20	28.30 (1.68)	30.68 (0.77)

†Mean (SD) of five samples tested with 50 L/min of air flow into patient connection port.

A significant increase in P_E at the patient connection occurred in nine of the configurations tested (ANOVA, p<0.0001). **Conclusion:** The addition of the Filter to the exhalation port of the 1st response appears not to increase the R_E to a clinically unacceptable level, i.e., only 0.82 cm H_2O over the ISO standard. The higher increase in R_E with use of the PEEP valve should be studied further to determine the imposed work of breathing when the 1st Response is used with the PEEP valve for oxygenation during spontaneous breathing.

OF-93-159

COMPARISON OF EXPIRATORY HOLD FUNCTION OF SIEMENS 900C VENTILATOR TO CLAMPING/TRANSDUCING METHOD IN DETERMINING INTRINSIC PEEP.

D. Madsen, RRT, M. Tweeddale MD, K. Jager RRT, Vancouver General Hospital, Vancouver, BC. Canada.

Various investigators have commented on the possible underestimation of intrinsic PEEP ($PEEP_i$) due to circuit volume distensibility when using the expiratory hold function on microprocessor ventilators. Although several ventilators incorporate this method of measuring $PEEP_i$, comparisons with other accepted methods have been infrequent. In this study, we examined the difference between the clamping/transducing method and the use of the expiratory hold function of the Siemens 900C in vitro. The Siemens 900C (Siemens Elema, Sweden) was connected to a test lung (TTL, Michigan Instruments Inc, Grand Rapids MI). Various compliances, minute volumes, flowrates and I:E ratios were used in order to create $PEEP_i$ levels from 4.O - 25.0 cm H_2O and circuit peak pressures from 19.0 -73.4 cm H_2O. At each setting of the test lung, three measurements of $PEEP_i$ were obtained by each of the two methods and compared by the paired t-test. The mean difference between the two methods was 0.13 ± 1.14 cm H_2O with a range of -2 to +2 cm H_2O. This difference was insignificant (p>0.5). Further analysis of the data showed that the mean difference between the methods was related to the absolute value of $PEEP_i$. Thus for $PEEP_i$ values ranging from 4.0 -10.0 cm H_2O, the mean difference was -0.59 ± -0.39 cm H_2O whereas for $PEEP_i$ values from 11.0-25 cm H_2O, the mean difference was +0.67 ± 1.23 cm H_2O. That is the expiratory hold technique tends to underestimate lower values of $PEEP_i$ and to overestimate higher values, although neither difference is clinically important and it has been our clinical experience that the two methods are equal. It is of our opinion that the expiratory hold function of the 900c ventilator can be used with confidence for the measurement of $PEEP_i$. The cost saving factor in comparison with the clamping/transducing method is substantial.

OF-93-206

AN IN VITRO COMPARISON OF 3 METHODS OF METERED DOSE BRONCHODILATOR DELIVERY TO INTUBATED ADULTS RECEIVING MECHANICAL VENTILATION.

Robert Harwood MSA RRT, Joseph L. Rau PhD RRT, Lynda Thomas-Goodfellow MBA RRT, Georgia State University, Atlanta, Georgia.

Aerosolized delivery of drugs offers a convenient route of administration for agents targeted to the respiratory tract. Mechanically ventilated intubated patients are frequently candidates for such aerosol therapy because of pre-existing acute pulmonary disease. A MDI offers an alternative to nebulized aerosol delivery, and has been found to produce equivalent clinical results when adrenergic agents are given. We report here the results of 3 methods of MDI delivery to mechanically ventilated intubated adults. Method: A Siemens Servo 900C in volume control was used to ventilate a lung model with standardized settings: MV was 9.6 L, RR was 12 bpm, IT was 20% or 1 sec. An 8.0 mmID ETT was attached to a rubber test lung (TL). The humidifier was bypassed. Aerosolized albuterol was delivered by MDI using three different methods. In method one the MDI was attached directly to the ETT inline between the wye and 15 mm adaptor using the Medicomp actuator/adaptor (MAA). In method 2 the MDI was attached to the Monaghan Aerovent reservoir (MAR) and placed on the inspiratory limb just proximal to the patient wye. Method 3 the MDI was attached to the DHD Aerosol Cloud Enhancer (ACE) and was placed as described in method 2. Drug exiting the end of the ETT was captured on cotton wadding, dissolved with alchohol, and measured using a spectrophotometer. Results, as percent of dose:

	$\bar{x}$ (%)	C.V. (%)
MAA	1.69 (.90)	53.6
MAR	19.75 (3.9)	18.2
ACE	47.01 (6.8)	14.5

Repeated measures analysis of variance for the 3 methods indicated they differed significantly ($p<.001$). Pairwise followup comparisons with Scheffe's Test showed that each method differed significantly from the other 2 ($p<.05$). Conclusion: Use of a reservoir device on the inspiratory limb increases the percent of dose reaching the end of the ETT. The DHD Aerosol Cloud Enhancer provided the greatest percent of dose.

OF-93-023

VEHICLE EFFECT ON VOLUME DELIVERY AND DRUG CONCENTRATION OF AEROSOLIZED ALBUTEROL

M. P. Hemstreet, M.D.; P. Simms, PhD., Pharm. D.; Don Creel, B.S., R.R.T.; M. Ingram, BSN. The Children's Hospital of Alabama, Birmingham, Alabama.

INTRODUCTION: The nebulization of β adrenergic agents is an important modality in the treatment of reactive airway disease. It is generally assumed that the rate of output of the aerosol and the drug concentration (dc) delivered over the period of nebulization are constant and that the vehicle used is irrelevant. METHOD: The volume delivery (vd) and the dc of normal saline (NS), 4% cromolyn sodium (CS), 1 mL albuterol (5 mg/mL) + 2 mL NS, 0.5 mL albuterol + 2.5 mL NS, and 1 mL albuterol + 2 mL. CS were determined at one minute intervals using the "Airlife Misty-Neb" nebulizer with a flow rate of 8 L/min. The mean output for all solutions was 0.56 mL/min. RESULTS: "Sputter time" (the spasmodic release of aerosol at 15-30s without visible release of aerosol) occurred between 4.5 to 6 mins. Thereafter the vd decreased to a mean of 0.1 mL/min. During nebulization the albuterol dc increased by an average of 40% in both albuterol/NS and by 10% in the albuterol/CS ($p=<0.05$). The initial average concentration of albuterol nebulized/min was less than 50% of the anticipated 1.67 mg/mL in both albuterol/NS solutions and never achieved the expected 1.67 mg/mL, whereas the albuterol/CS mixture was initially 17% greater than and never fell below 1.67 mg/mL. The concentration of albuterol was measured by high performance liquid chromatography and the area under the curve determined. All samples were run in duplicate. CONCLUSIONS: The above data suggest that nebulization beyond "sputter time" is unproductive and that cromolyn sodium may allow a more constant delivery of drug.

OF-93-026

SVN TO MDI CONVERSION: SIX YEARS OF COST SAVINGS

Dominic P. Coppolo, RRT, Michael A. Bauer, MD, Bassett Hospital, Cooperstown, N.Y.

Hospitals must consider alternative methods of aerosol delivery as a cost savings. This study examined conversion from small volume nebulizer (SVN) to metered dose inhaler (MDI) in a mid-sized community hospital and evaluated actual cost savings from 1987-1992. We retrospectively reviewed yearly data from 1988 through 1992 and we calculated all associated costs of labor, equipment, and medication. A linear regression model was used to predict the cost per treatment based on the percent of MDI's used. Conversion to a primary MDI delivery system was accomplished by respiratory therapist driven protocol and ongoing patient and physician education. Results of this study showed the combined total number of aerosol therapy treatments increased from 10,503 to 20,458 during a six year period. MDI therapy in 1987 comprised less than one percent of the total and increased continually over 6 years to 65% of the total aerosol therapy given by the end of 1992. Our linear regression model indicates that every one percent increase in the use of MDI's results in a cost reduction of 2 cents per treatment ($p=.0007$). During a five year period, our hospital realized a total of $72,656 in cost savings. Although SVN treatments are utilized when clinically indicated, the conversion to a predominate MDI delivery system for hospitalized patients has resulted in significant cost savings.

OF-93-033

INCONSISTENCIES IN METHODS OF MEDICATED AEROSOL DELIVERY: A CITY-WIDE SURVEY.

Lucy Kester MBA RRT, Dennis Giles RRT, James K. Stoller MD. Cleveland Clinic Foundation, Cleveland, Ohio.

Although many reports have demonstrated the value of medicated aerosols, differing conclusions about the best method of delivery may give rise to widely varying practices. To assess variation in the practice of using medicated aerosols in a single metropolitan area, we conducted a telephone survey of respiratory therapy managers in 24 Cleveland area hospitals in March 1991. Questionnaires were administered by two therapists (LK, DG) and elicited information about hospital size, approximate numbers of aerosol treatments given per year, the use of MDIs and spacer devices, and who determines the type of delivery device. Data were collected from hospitals of varying size (110 to 900 beds). The number of aerosol treatments/yr varied greatly among respondents (16,000 to 156,000) and did not correlate with hospital size. In 20 of the 24 hospitals (83%), metered dose inhalers (MDIs) were used for at least some patients. The type of aerosol delivery device was physician-directed in 75% of the hospitals. Suggested MDI techniques varied greatly (i.e. 7 hold in mouth, 8 hold away from mouth, 5 not specified) as did the use of spacer devices (3 always, 4 sometimes, 13 as needed). In 13 hospitals, small volume nebulizers (SVNs) were used exclusively in the emergency room, but in 11 hospitals MDIs were used sometimes in ER. Based on this survey of 24 hospitals in a single city, we conclude: 1. Great variation exists in delivery of aerosolized bronchodilators, 2. Lack of correlation between hospital size and number of aerosolized medications suggests varying indications for using aerosolized bronchodilators, 3. As of the study date (March 1991), physicians, rather than therapists, directed the type of delivery device in most (75%) of the surveyed hospitals.

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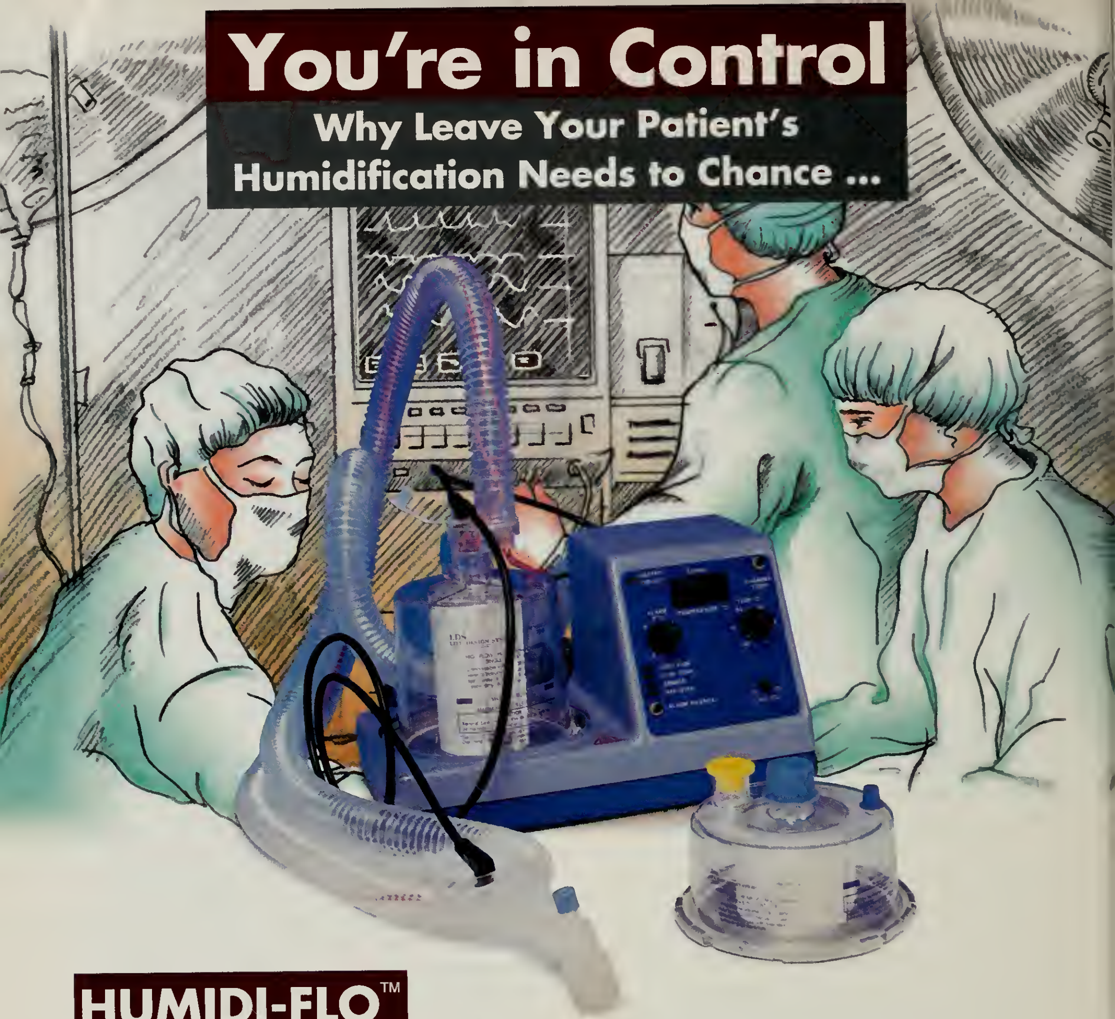

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CLINICAL COMPARISON OF TWO AEROSOL HOLDING CHAMBERS: ACE VS AEROCHAMBER.

R.J. Perry B.S., E.G. Langenback Ph.D. and J.S. Ilowite M.D. Pulmonary Divisions, SUNY at Stony Brook, NY 11794 and Winthrop-University Hospital, Mineola, NY 11501.

Aerosol holding chambers (HC) have proven to be an effective enhancement to Metered Dose Inhaler (MDI) therapy. Recent bench tests demonstrating different performance characteristics between HC's with unknown relevance regarding clinical efficacy suggests the need for patient studies confirming each new HC-MDI combination. The present study compares the clinically accepted Aerochamber® with the ACE™ Aerosol Cloud Enhancer both combined with albuterol MDI administered to asthmatics. To enter the protocol a subject first demontrated a bronchodilator response of at least 15% (increase in FEV1) to Ventolin® unit dose via Hospitak Power-Mist™ nebulizer. On seperate study days 4 subjects inhaled 2 puffs of Ventolin MDI through each HC after withholding all asthma medications for 8 hours. All spirometry was performed pre and 30, 60 and 120 minutes post bronchodilator. Pulse, blood pressure and incidence of side effects were also recorded. Bronchodilation was assessed via change in FEV1 using a "% possible" index which normalizes for differences in the baseline FEV1 between study days. ΔFEV1%pos is defined as the difference between the baseline and post FEV1 divided by the difference between the predicted and baseline FEV1and was calculated for each time point. Mean ΔFEV1%pos ± S.E. at T=30, 60 and 120 minutes were as follows. Nebulizer: 40.0±8.0, 40.2±5.9, 35.1±5.3; ACE: 37.9±7.1, 32.6±9.2, 18.7±8.3 and Aerochamber: 17.7±7.6, 15.4±7.4, 23.2±6.1. This data verifies the efficacy of the ACE/Ventolin MDI combination. The greater ΔFev1%pos observed at 30 and 60 minutes (p=0.05 & 0.01 paired t-test) in the ACE over the Aerochamber may be explained by differences in design in the two HC's. The ACE may be delivering smaller particles to more responsive areas of the lung resulting in greater bronchodilation. It is also possible that the differences observed are due to the low number of subjects completed to date. Since the jet nebulizer demonstrated a more sustained bronchodilator effect at 120 minutes than either HC the potential exists for future HC combinations with new long acting bronchodilator agents.

OF-93-094

EFFECT OF CHANGING COMPLIANCE, EXPIRATORY RESISTANCE, AND INSPIRATORY FLOW PATTERN WITH THE VISAN-9 NEBULIZER—Carl F Haas, MLS, RRT, John G Weg, MD, FCCP. University of Michigan Medical Center, *Ann Arbor, MI*, David S Zaccardelli, PharmD. Burroughs Wellcome Co, *Research Triangle Park NC*

This study evaluated the effect of changing lung compliance (C), expiratory resistance (R) and inspiratory flow pattern with a nebulizer used during a synthetic surfactant therapy study in ARDS. The nebulizer fills the ventilator's inspiratory circuit with aerosol during early expiration, using a 50 L/m flow. **Methods:** A nebulizer (VISAN-9, Vortran Med Tech, Sacramento CA) was electrically connected to a ventilator (7200a, Putitian Bennett, Carlsbad CA) and set to nebulize 0.6 L/breath. The ventilator had a VT=0.6 L, f=20, FIO2=0.5, flowrate=50 L/m and was connected to a spring-loaded test lung (VentAid TTL, Michigan Instruments, Grand Rapids, MI). A pneumotachometer (VarFlex, Bicore Monitoring Systems, Irvine CA) was placed at the test lung connection. The following measurements were taken with the nebulizer off and on: a 40-breath printout containing peak inspiratory (PIP) and mean airway (MAP) pressures, VT, PEEP, peak expiratory flowrate (PEFR); and the pressure, volume, and flow waveforms from a respiratory mechanics monitor (CP-100, Bicore). Pressure, and flow waveforms were obtained from the ventilator's graphics package. R was applied using a tube in the expiratory limb clamped to produce 4, 10, 20, and 30 cm/H2O per 100 L/m flow, and the ventilator PEEP adjusted to 4, 10, 20 and 30 cm H2O. With a clamped-tube R of 0, 4, and 10 cm H2O/100 L/m flow, test lung C was adjusted to 10, 25, 40 and 60 mL/cm H2O and inspiratory flow adjusted to both square and decelerating patterns. **Results:** During normal operation of R=0, the nebulizer slightly increased the PIP (2.7 ± 2.2%), VT (3.3 ± 2.1%), and PEEP (0.7 ± 0.5 cm/H2O) and moderately increased MAP (11.3 ± 3.4%), and the actual time required to exhale (22.3 ± 7.5%). PEFR decreased by 7.0 ± 6.8%. This effect was exaggerated by increasing C and R, and by the decelerating flow pattern. The flow waveform showed a reduced early expiratory flowrate with nebulizer on, which worsened with increasing C and R (applied as a flow resistor). R applied via PEEP (threshold resistor) did not effect the early expiratory flow pattern. **Conclusions:** Exhaling against the nebulizer flow increased MAP, and the actual time to fully exhale— potentially leading to auto-PEEP. Care must be taken to allow adequate exhalation, especially at higher compliance levels. (Sponsored in part by Burroughs Wellcome Co.)

OF-93-096

PULMONARY DEPOSITION OF PENTAMIDINE (P) DELIVERED BY METERED DOSE INHALER (MDI) COMPARED TO RESPIRGARD II NEBULIZER (NEB)—Kandal K, BA, RRT; Brown CR, MD; Harris RA, CRTT; Price KJ, CPFT; Snow MG, RPFT; Fallat RJ, MD. California Pacific Medical Center, San Francisco, CA.

Introduction: Levels of pentamidine were measured in BAL specimens from subjects receiving aerosolized P from Neb or from MDI. **Methods:** An MDI capable of delivering 1.1 mgs of P per puff with 30% in the respirable range of 1-5μm MMAD was tested. In our prior studies, 14 healthy HIV+ subjects inhaled 120 puffs of P over 40 min., 7 subjects inhaled 300 mg P from Neb over 40 min., and 7 subjects inhaled 240 puffs over 2-4 hrs. Albuterol was given prior to dosing. BAL with 180 ml saline was performed 24 hrs. and 28 days after dosing. BAL was centrifuged and P was measured in supernatant (S) and cell pellet (C) by high performance liquid chromatography. Similar levels of P were found in S & C in all 3 groups. In the current study, 35 AIDS patients eligible for PCP prophylaxis were randomized to 300 mg Neb on days 1 & 28 or 120 puffs from MDI followed by 8 or 24 puffs/d for 56 days. BALs were done on days 2, 28, & 56 prior to Neb dose or daily puffs. Two patients were dropped from the study: one for non-compliance and another after diagnosis of PCP from 24 hr BAL. **Results:** At 56 days, levels of P in S were significantly higher in the two MDI groups (12.0, 8 puffs; 28, 24 puffs) than in the Neb group (3.5 ng/ml). The P in C was similar between Neb & 8 puffs, but significantly higher in the 24 puff group (57, 8 puffs; 144.2, 24 puffs, 45.6 Neb). Moderate cough was reported in one patient in each MDI group, moderate asthma in one patient on 24 puffs, but treatment was not altered. **Conclusions:** P delivered by either 8 or 24 puffs/d by MDI is well tolerated and results in significantly elevated P in BAL after 28 and 56 days of daily dosing. Prophylaxis may be improved by use of MDI rather than Neb. More prolonged evaluations are indicated and ongoing.

OF-93-119

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AEROSOL PARTICLE SIZE GENERATED BY RAINDROP NEBULIZER. Thomas Barnes EdD RRT, Nancy Chen PhD, Eric Mack PhD, Northeastern University, Boston, MA. We evaluated the mass mean aerodynamic diameter (MMAD) generated by the Puritan-Bennett Raindrop nebulizer P/N 001140 (SVN). **Method:** the SVN was evaluated with a Tee and mouthpiece with aerosol measured at mouthpiece outlet. The gas flow to the SVN was 6, 7, and 8 L/min. $\dot{V}$ was verified with a calibrated Timeter RT-200. The SVN was also evaluated with a fixed output portable air compressor. A calibrated 6-stage cascade impactor, California Measurements Model AS-6 (through which air was drawn at 12.5 L/min), was used to characterize aerosol generated by the SVN was fitted with an evaporation chamber (EC). EC was modified from a 3-L round-bottom distillation bottle (diameter 16 cm) by addition of another port. The SVN was tested using disodium fluorescein dissolved in normal saline (DF). The concentration of the DF solution was 3.49 mg/mL. Aerosol was generated for 15 s with 4.3 mL of DF in the SVN. DF deposited in the EC and each stage of cascade impactor was determined spectrophotometrically at 488.5 nm and used to calculate MMAD and geometric standard deviation (GSD). **Results:**

Particle Size From Raindrop Nebulizer†

Flow (L/min)	MMAD (uM)	GSD (uM)
6	1.04 (0.14)	2.05 (0.11)
7	1.08 (0.18)	1.94 (0.17)
8	1.10 (0.25)	1.96 (0.19)
Compressor	1.03 (0.24)	1.88 (0.17)

†Mean (SD) three replicates of three samples.

No significant difference in MMAD and GSD existed at the flows tested (ANOVA, p = 0.8840 and 0.1889 respectively). **Conclusion:** The Raindrop SVN with flow of 6-8 L/min appears to generate aerosol particles with MMAD that are appropriate for delivery of aerosol medications to the lung periphery. Flow from a fixed output portable air compressor appears to produce MMAD similar to that found with 6-8 L/min from a calibrated flowmeter.

OF-93-158

ADAPTER ORIENTATION EFFECT ON MDI DOSE

William W. Quinn- RPFT RRT Ochsner Foundation Hospital New Orleans, Louisiana. Most adapters for administering metered dose inhalers (MDIs) to ventilator patients direct the puff towards the patient. On the other hand, the DHD ACE directs the puff away from the patient, back into the inspiratory limb of the circuit. I sought to determine whether a change in this orientation would produce a measurable difference in particle delivery to a test lung. Method: A laser particle counter (LPC) was adapted to a Training Test Lung (TTL) in such a way that a sample could be aspirated at end-exhalation from the TTL into the LPC after clamping the endotracheal tube (ETT) shut to prevent aspiration from the circuit. A secondary port fitted with a PALL filter and a one-way valve was created to establish a vent to enable the LPC to draw the sample after clamping the ETT. Five different therapists were instructed to actuate the MDI in three different trials of two different actuation protocols, so that 15 trials of each protocol were obtained. Protocol 1(P1) was actuation with the ACE pointing away from the patient connection (as the manufacturer intends) prior to a mechanical breath of .8 L. Protocol 2(P2) was actuation with the ACE reversed, pointing towards the patient connection prior to a mechanical breath of .8 L TV. Results, in millions of cubic microns (SD)- P1: 0.48 (.08) P2: 0.45(0.06) Results exhibit a marginally significant difference, $p=.44$, by ANOVA. Conclusion: I was unable to confirm with this test that the reverse orientation of the ACE MDI adapter is a major factor in enhancing dose delivery to the ventilator patient.

OF-93-160

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VENTILATOR BREATH EFFECT ON MDI DOSE

William W. Quinn RPFT RRT Ochsner Foundation Hospital New Orleans, Louisiana. I sought to determine what variation existed in particle delivery from a metered dose inhaler (MDI) in a ventilator circuit that could be attributed to differences in type of breath employed. Method: A laser particle counter (LPC) was adapted to a Training Test Lung (TTL) in such a way that a sample could be aspirated at end-exhalation from the TTL into the LPC after clamping the endotracheal tube (ETT) shut to prevent aspiration from the circuit. A secondary port fitted with a PALL filter and a one-way valve was created to establish a vent to enable the LPC to draw the sample after clamping the ETT. Four different breath types were tested. In the first two fifteen different therapists were instructed to actuate the MDI in three different trials so that 45 trials of each breath type were obtained. In the third and fourth type, five therapists performed three trials each, for a total of 15. Type 1(T1) was actuation immediately prior to a simulated spontaneous tidal volume (TV) of 350 ml and a 25 L/min flow. Type 2 (T2) was actuation at a therapist timed point prior to a mechanical breath (MB) of .8 L TV with 50 L/min flow. Type 3 (T3) was actuation prior to a pressure support breath of 10 cm H2O (.5L TV). Type 4(T4) was actuation prior to an MB of .8 L TV with 25 L/min flow. A DHD ACE adapter was used throughout. Results, in millions of cubic microns(SD)- T1: 0.89(.01) T2: 0.48(0.08) T3: 0.64(.05) T4: 0.60(.09). T1 yielded a significantly higher respirable volume of particles than all other breath types, $p<0.01$ by ANOVA. T3 and T4 yielded significantly more than T2, by the same criterion. Conclusion: More drug is delivered with a spontaneous TV of .35 L than with an MB of up to .8 L TV. The degree of peripheral deposition cannot, however be confirmed by this model. Additionally, MDI use with reduced flow on the MB would enhance drug delivery to an apneic patient.

OF-93-161

TESTING OF A NEW MDI ADAPTER

William W. Quinn RPFT RRT Ochsner Foundation Hospital New Orleans, Louisiana. I sought to compare performance of a metered dose inhaler (MDI) adapter marketed for use in a ventilator circuit to adapters whose performance has previously been reported. Method: A laser particle counter (LPC) was adapted to a Training Test Lung (TTL) in such a way that a sample could be aspirated at end-exhalation from the TTL into the LPC after clamping the endotracheal tube (ETT) shut to prevent aspiration from the circuit. A secondary port fitted with a PALL filter and a one-way valve was created to establish a vent to enable the LPC to draw the sample after clamping the ETT. I tested four MDI adapters five times each, activating the inhaler immediately prior to a .8 L mechanical breath. Results, in millions of cubic microns(SD): 1)Ballard Trachcare 118 .09(.01) 2)DHD ACE .55(.05) 3)Baxter 002063 Inline Adapter .46(.06) 4)Hudson 1659 Inline Adapter .48(.03) The Ballard 118 delivered significantly less ($p<.001$, by ANOVA) than all other devices tested. Conclusion: The Ballard 118 delivered far less medication then any other device tested and cannot be recommended for clinical use. Otherwise, the test replicates previous findings that a spacer-type adapter such as the ACE delivers more medication than a 22 mm in-line fitting.

OF-93-163

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A Comparison of Metered-Dose Inhaler and Continuous Nebulizers in Treating Acute Asthma Exacerbation

Elaine Gambrioli, BS, RRT, Jim Fink, RRT, Andy Levitt, MD, UCSF Medical Center, San Francisco, CA.

Introduction: Standard dose and frequency of nebulized bronchodilators often fails to provide relief of the asthmatic in acute exacerbation. We compared dose titration using metered dose inhalers with spacers (MDI), and high dose continuous nebulization (CONT) with albuterol (Proventil, Schering) to determine relative efficacy and safety in treating patients with acute bronchospasm. Method: Double blind randomized placebo controlled study of 40 adult patients in the Emergency Department (ED) presenting with acute exacerbation of asthma. Treatment was either CONT therapy of 15mg/hour or up to 24 puffs/hour of MDI (6 series of 4 puffs with 60 seconds between puffs and > 5 minutes between series) for up to 3 hours with data collected q30 min. Medications were prepared in advance by the pharmacy, and masked from the study participants.

Results: The two groups varied significantly in age (mean age CONT 41.6 and MDI 60.7 years) but presented with similar levels of severity on the Borg Scale (4.8 CONT, 4.2 MDI) and identical average scores of 1.4 at end of protocol. Table 1 demonstrates the clinical response in patients with improvement greater than 10% above baseline with peak flows, $FEF_{25\text{-}75}$ and FEV_1/FVC. No significant changes in blood pressure or respiratory rate occurred with either group. Mean pulse rates varied from 91 - 112bpm with 3 patients developing significant tachycardia in each group. Mild to moderate tremors developed in 6/20 MDI and 9/20 CONT. 2/20 CONT developed arrhythmias. No adverse effects required treatment. 14/20 in the CONT group and 12/20 MDI group were discharged to home One patient in the CONT group was intubated for airway protection secondary to a pre-existing siezure disorder. Discussion: The role of bronchodilator therapy is to provide maximum relief as quickly as possible. While 10 -20% improvement in monitored parameters are considered adequate in chronic stable asthmatics, improvements of up to 300% of baseline can be life saving during acute exacerbation. Conclusion: Both treatment strategies yield substantial improvement in pulmonary function and relief of subjective symptoms with comparable therapeutic end points, resulting in no significant compromise to the patient due to adverse response to the higher than standard dosages being used.

TABLE 1 : INCREASE IN MEASURED PARAMETERS

	CONT	MDI
PEAK FLOW		
N withImprov>10%	(17)	(13)
Range of improvement.	112% - 325%	113 - 348
Mean Improvement.	164%	188%
$FEF_{25\text{-}75}$		
N withImprov>10%	(10)	(13)
Range of improvement.	112% - 380%	113 - 381
Mean Improvement.	218%	205%
FEV1/FVC		
N with Improv>10%	(8)	(7)
Range of improvement.	117% - 192%	112 - 148
Mean Improvement.	141%	121%

OF-93-167

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TIMING MDI ACTUATION ON THE VENTILATOR

William W. Quinn RPFT RRT Ochsner Foundation Hospital New Orleans, Louisiana. I sought to determine what variation existed in therapists' timing in actuating metered dose inhalers (MDIs) on ventilator patients and to measure whether variations existed in particle delivery to a lung model that could be attributed to differences in timing. Method: A laser particle counter (LPC) was adapted to a Training Test Lung (TTL) in such a way that a sample could be aspirated at end-exhalation from the TTL into the LPC after clamping the endotracheal tube (ETT) shut to prevent aspiration from the circuit. A secondary port fitted with a PALL filter and a one-way valve was created to establish a vent to enable the LPC to draw the sample after clamping the ETT. A thermistor at the actuation point was used to generate a temperature signal to a two-channel strip chart recorder, the other channel of which received a pressure signal from the ventilator, so that timing of the actuation relative to the breath could be established. Fifteen different therapists were instructed to actuate the MDI in three different trials of two different actuation methods, so that 45 trials of each method were obtained. Method 1 (M1) was actuation immediately prior to a therapist-activated mechanical breath. Method 2 (M2) was actuation at a therapist-timed point prior to a machine activated breath. A DHD ACE adapter was used throughout. Results(SD), in millions of cubic microns: M1- 0.55(.07) at an average time .47 (.18) seconds before the breath. M2- 0.48(0.08) at an average time 1.4 (1.4) seconds before the breath. Difference was significant by ANOVA, $p<.05$. Linear regression analysis showed a significant correlation between increased time from actuation to breath and reduction in dose, $R=.62$ $p<.001$. Conclusion: Techniques for MDI use should minimize time lapse between MDI actuation and ventilator breath. Manual actuation of the breath appears to accomplish this goal.

OF-93-192

CHOICE OF MECHANICAL VENTILATOR: INFLUENCE ON NEBULIZER PERFORMANCE—

Michael McPeck BS RRT, Thomas G O'Riordan MD MRCPI, Gerald C Smaldone MD PhD. Departments of Respiratory Care and Medicine, Pulmonary/Critical Care Division, University Hospital, State University of New York at Stony Brook, Stony Brook, New York.

STUDY QUESTION: Do the nebulizer (neb) drive characteristics of mechanical ventilators influence aerosol delivery (AD)? **METHODS:** Using a test bench protocol incorporating an ETT and test lung, the aerosol generated by 2 different jet nebs, charged with radio-labeled (99mTc) saline solution was measured. A low resistance absolute filter was used to collect the radioaerosol delivered to the distal tip of the ETT, the quantity of which was expressed as a percentage of the neb charge (inhaled mass%). Airlife and Hudson nebs were selected for testing and 4 contemporary ventilators (Bear 1000, Hamilton Veolar, Infrasonics Adult Star, and Puritan-Bennett 7200ae) were set at f=15/min, V_T=1000 mL, square inspiratory flow pattern, inspiratory flowrate=45 L/min (I:E=1:2; inspiratory time fraction=33%) for all experiments. Humidification was not used as this has been previously shown to reduce AD. Serial measurements over time of filter radioactivity were made with each nebulizer until cumulative radioactivity reached a plateau; the results at each interval were graphed and expressed as a percentage of the activity initially placed in the neb. In addition to AD, we also measured the pressure generated int he neb drive line proximal to the neb during inspiration and the gas flow through the neb using a pneumotachograph and recorder. **RESULTS:** AD to the ETT filter varied over a wide range with values between 3.2 and 3.6% for the Hamilton and 9.6 to 14.7% for the other ventilators. Driving pressure and flow varied in a similar manner with values measured for the Hamilton that were lower than the other brands. The time to complete nebulization appeared related to driving pressure with the high pressure ventilators completing the treatment in 1/3 the time (30 mins vs 90 mins). **CONCLUSION:** The choice of mechanical ventilator has an important influence upon the efficiency of jet nebulization within a ventilator circuit. Driving pressure and flow to the neb can significantly affect nebulizer performance and treatment duration. Therefore, in designing a protocol to deliver a nebulized drug to a ventilated patient, the choice of ventilator must also be taken into account together with previously identified variables including choice of nebulizer, ventilator settings, and humidification.

OF-93-193

PREDICTION AND ASSESSMENT OF BRONCHODILATOR RESPONSE IN MECHANICALLY VENTILATED PATIENTS.

P. J. Shafer, RRT, C.L. Kasper, RRT, M.J. Bishop, MD, D.J. Pierson, MD. Harborview Medical Center, Seattle, WA.

Bronchodilators (BD) are commonly prescribed for mechanically ventilated (MV) pts, yet uniform indications for, and objective assessment of, the efficacy of this therapy are generally lacking. In the following prospective study of consecutive MV pts, we asked the following questions: Does the routine use of BD result in identifiable improvement in all pts? Can we identify *a priori* those pts most likely to respond? METHODS: The 54 tracheally intubated pts (41 M, 13F; age range 3-98) were from the surgical/trauma (22), medical/coronary (19), Burn (4), and neurosurgery (9) ICU's. Before and 15 min. after the first dose of BD in these pts, we recorded auto-PEEP, PIP, Pst and the presence of wheezing on auscultation. Evidence for the presence of reversible airway obstruction (RAO) (diagnosis of COPD or asthma; use of corticosteroids or BDs) was sought from the medical history. The BD was delivered via metered dose inhaler and Aerovent chamber as prescribed by the primary physician. 38 patients received 20 puffs of Albuterol, 7 also received 20 puffs of Ipratropium Bromide, 14 pts. received 10 puffs of Albuterol, 5 also received 10 puffs Ipratropium Bromide, 2 pts received 6 puffs Albuterol. In analyzing the data, we considered an acceptable indication for BD therapy to include either a possible h/o RAO, the presence of auto-PEEP, or the presence of wheezing. A positive response to BD was defined as a subjective decrease in wheezing, > 2 cm H2O decrease in auto-PEEP, or >4 cmH_2O decrease in PIP. RESULTS: 42/54 (78%) pts had at least one indication for BD. Of these 42, 27 had at least one of the 3 response criteria. Of the 12 pts without an indication only 1 met a response criterion. ($P<0.01$ by chi square). Of the pts who were not wheezing prior to treatment, only 5 of 20 showed decreased PIP or auto-PEEP, whereas 21 of 31 who were wheezing met at least one of the response criteria ($P < 0.01$). A presumptive history of RAO did not predict BD response: 7/16 pts with (+) history and 19/38 pts with (-) history responded. CONCLUSIONS: Our data confirm other studies showing that BD response can be detected and quantitated in MV pts using routine bedside assessments. However, using the information often available to the clinician (eg: limited patient history, physical exam, PIP and auto PEEP), it is not possible to predict reliably which patients will benefit from BD treatment. Based on the results of this study we recommend an empirical trial of BD in MV pts for whom a potential indication exists. In the absence of such an indication, or if objective measurements fail to document a response, continued BD administration may not be cost-effective.

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COST SAVINGS BY VERIFYING PULMONARY FUNCTION TEST ORDERS—George Blaisdell, Jr., CRTT, CCPT-R-PFT, Tim Blanchette, MS, RRT, Maine Medical Center, Portland, Maine

We found that ordered pulmonary function tests (PFTs) were often more extensive, time consuming and expensive than needed to provide the physician with the information he/she required . This study examined the excess costs encountered when full PFTs (consisting of lung volumes, flow/volume loop, MVV, airway resistance via body plethysmography, post-bronchodilator flow/volume loop in obstructed patients) were initially ordered, then subsequently modified to less extensive tests after physician consultation. Method: During the period of June-September 1992, 103 orders for full pulmonary function studies were received in our lab. In 37 cases, diagnostic data (most often a question of fibrosis causing therapy) indicated that less extensive PFTs could probably provide adequate information. In these cases the pulmonary function technician called the ordering or attending physician and discussed what information was required from the tests. All 37 of these PFT orders were modified, yet yielded all necessary information for the physician. The cost to perform the tests as originally ordered and subsequently modified (most often including spirometry and DLCO only) were calculated. Results: The cost for 103 full pulmonary function studies ($217 each) for this four month period would have been $22,351. The average cost for the 37 modified orders was $74 or a savings of $143 per patient. The actual cost for the studies on the 103 patients was $17,094 for a total savings of $5,257. The annual savings expected by evaluating and verifying PFT orders in our institution would be $15,771. Conclusions: Extensive PFTs are time consuming, costly and may be inadvertently or unnecessarily ordered. Substantial cost savings can be achieved by questioning and verifying PFT orders for accuracy and appropriateness prior to performing tests.

OF-93-003

JOB DESCRIPTION CONFLICT & AMBIGUITY AMONG RCP MANAGERS IN CALIFORNIA—Larry Boutcher, PhD, RCP, RRT. Educational Consultant, San Diego, California.

As we enter the 21st century, the hospital manager must be better prepared to face change within the national healthcare system than his predecessors. A hypothesis was proposed that by the nature of their work, RCP department managers would demonstrate considerable role conflict and ambiguity. Job description conflict was defined as antagonism or opposition between the manager's interests or principles compared to the specific contents of a professional job description. Job description ambiguity was defined as doubtfulness or uncertainty as to the meanings or indications outlined within the professional job description. According to resources, there are 548 hospitals within California. A random sampling of 150 were mailed a survey. A 7-point Likert scale developed by Rizzo (1970), and subsequently validated by Schuler (1977) and Van Sell (1981), was the tool used to elicit the responses. A return of slightly over 49% was achieved. Based upon Rizzo's, Schuler's, and Van Sell's research, a 4.0 was determined to represent a neutral score. A Mean Job Description Conflict Score (MJDCS) and a Mean Job Description Ambiguity Score (MJDAS) were calculated from the responses. Mean & standard deviation score comparisons, in conjunction with the Student's t test, were utilized to determine significance. The hospitals surveyed ranged in size from 44-589 beds (average 169). The average department size was 15-35 RCPs. 81.5% of the managers were of Caucasian heritage. The ratio of male to female managers was 63% to 37%.

MJDCS = 4.10 (S.D. 1.03)
MJDAS = 2.70 (S.D. 0.96)

Conclusion: The random sampled group of California RCP managers showed an overall neutral MJDCS. This is consistent with studies of nurse executives but not consistent with studies of medical records managers. However, several questions demonstrated a significant level of potential job overload. indicating that although these RCPs do not necessarily struggle with a conflict issue, they do have concerns regarding the time frame for completion of individual tasks. The overall MJDAS was low, suggesting that these managers are not concerned with the behavioral requirements of their position. OF-93-007

EFFECT OF A WEANING EDUCATIONAL PROGRAM ON COST OF CARE IN THE POST OPERATIVE CARDIAC SURGICAL PATIENT

Mary E. Egloff, MSN, RN, CCRN, Patricia Sheridan, MSN, RN, Gwen S. Dyson, RCP, RRT, CCVT, AS, Cheryl Dailey, BSN, RN, CCRN, CNRN, Linda Ryan-Nicklas, MN, RN, CCRN, S. Mali Sharveh, MSN, RN, Charles F. Landers, MD.
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Introduction: The purpose of this study was to examine the effect of a two hour educational program which focused on weaning and extubation of the post operative cardiac surgical patient. The content of the class included: appropriate use of sedatives and vasodilatory drugs, stimulation of wakefulness, and a suggested weaning protocol. The class was mandatory for all surgical intensive care unit (SICU) nurses and respiratory therapists (RT) caring for cardiac surgical patients. This program was offered live and then video taped for staff who were unable to attend the live sessions. **Method:** All stable cardiac surgery patients were eligible for inclusion into the study. Patients were excluded due to severe post operative complications and incomplete medical records. Cost of the program was defined as the number of arterial blood gases (ABG) drawn during intubation while in the SICU and the first 24 hours post extubation, ventilator related costs during intubation, length of stay in SICU, length of stay in the hospital and education of the staff. Cost was evaluated in 125 cardiac surgical patients, with or without valve replacement, before (n=62) and 2 months after (n=63) the educational program. A retro-spective chart review was performed by three of the researchers to collect the data. Interrater reliability was 96%. **Results:** Following the intervention, a mean of 1.1 less ABG's were drawn (t=3.37, df=122, p=.001) for a cost savings of $1386 ($20/ABG) for the 63 patients studied. The educational program was estimated to cost $3,230 based on the length of the class (1.5 hours), attendee mean salaries (60 RN @$22/hr; 30 RT @$18/hr) and instructor time (20 hrs @ $22/hr). No difference was found in ventilator related costs during intubation, length of stay in SICU and length of stay in the hospital. **Conclusion:** Although the cost of the intervention exceeded the savings in the 63 patients studied, the break-even point would be 1.1 less ABG's in 147 patients. This suggests that after a decrease of ABG's in 147 patients, this educational program can begin to save money for the hospital.

OF-93-017

INAPPROPRIATE ORDERING OF ARTERIAL BLOOD GASES BY PHYSICIANS IN A SURGICAL INTENSIVE CARE UNIT:

M Santoro RRT, J Sestito RRT,
J Cowen MD, S Craemer RRT,
L Gradwell RRT, H Palevsky MD
University of Pennsylvania Medical Center
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The purpose of this study is to determine whether physicians used appropriate criteria for ordering arterial blood gases (ABG) in a Surgical Intensive Care Unit (SICU). METHODS: We monitored the indications for obtaining all ABG's in a 32 bed SICU for one week time period. RESULTS: During the one week time period 465 ABG samples were obtained from 67 patients. Three-hundred seventeen (68.2%) of all ABG samples were drawn from patients who were mechanically ventilated. Two-hundred and sixty two (56.3%) samples were acquired without physician orders. Two-hundred three (43.7%) samples were obtained as the result of a physician order. Nintey-six (47.3%) of all physician ordered (PO) ABG's were acquired for the purpose of routine documentation (no physiologic, and or metabolic change). Seventeen (8.3%) of all PO ABG samples were obtained to assess the response to a change in oxygen therapy. Twenty (9.8%) of all PO samples were obtained as admission studies to assess initial ventilator parameters. Forty-eight (23.6%) of all PO ABG's were obtained to assess the effects of a change in ventilator settings. Twenty-three (11%) of all PO ABG's were obtained to assess changes in patients condition. CONCLUSION: The PO ABG's obtained to assess initial ventilator parameters, changes in ventilator settings or a change in patient condition (41.7% of PO ABG's) appear to be warranted. However, PO ABG's acquired for routine documentation, or to assess oxygen therapy changes are probably not justified. Our results show that a physicians order does not guarantee appropriate utilization of laboratory resources. Implementation and education of specific guidelines in the acquisition of ABG's, and the placement of pulse oximeters at each patient bedside should significantly reduce the unwarranted acquisition of ABG's.

OF-93-024

ANALYSIS OF RESPIRATORY CARE ORDERING PRACTICES FOR INTERMITTENT AEROSOL THERAPIES (IAT) AT DUKE UNIVERSITY MEDICAL CENTER.

Janice Thalman, BS, RRT, Susan Rinaldo-Gallo, MEd, RRT, Robert McConnell, BS, RRT. Duke University Medical Center, Durham, NC.

Introduction: The current Respiratory Care (RC) order review process does not include automatic discontinuation (D/C), standards for duration, or forced intervention criteria. Our service performed 365,256 intermittent aerosol treatments (IAT) in 1992 (inclusive of small volume nebs (SVN) and metered dose inhalers (MDI)). To justify a more formal procedure/order review system an analysis of the following was completed: 1. Average number of patient hospital days on IAT therapy. 2. Frequency and type of changes made to original orders. **Method:** An analysis of 104 patients with active IAT orders was completed. This represents 45 days and 1063 treatments. Patients were from 3 clinical services: medicine, pediatrics, and surgery. Only intermediate care areas were reviewed. **Results:** Table I: Statistical Results of Ordering Practices for Intermittent Aerosol Therapy (IAT) From All 3 Clinical Services.

	All Services
Treatments	1063
*Average Days on Respiratory Therapy	10 days
Orders Active at Discharge	86 (83%)
Orders Discontinued Before Discharge	14 (13%)
Patients Admitted to ICU	4 (4%)
Average Days on Original Order	7
Changes in Modality	41
Changes in Frequency	103
Frequency changes to prn	10 (63%)
SVN orders changed to MDI	4 (36%)

*Average patient length of stay for institution is 8
+ Patient ability to perform MDI limited in children

Conclusions: A formal procedure/order review system by Respiratory Care Services is needed in the form of automatic (D/C), standards for duration of therapy, and forced intervention criteria. This was evidenced by: 1. The high percent of patients discharged on active RC orders. 2. The average number of days patients received IAT. 3. The high number of order frequency changes to PRN. 4. The average number of days until a change was made to the original order.

OF-93-091

IMPACT OF THERAPIST DRIVEN BRONCHODILATOR PROTOCOL

—Teresa J. Keppler, BBA, RRT, Carl F Haas, MLS, RRT, Mark A. Konkle, MPA, RRT, John G Weg, MD, FCCP. University of Michigan Medical Center, *Ann Arbor, MI*

In 1982, a bronchodilator therapy (BDT) protocol was initiated. In spite of this, 31% of therapy did not meet indications (22,500 annual BDT's). In May 1993, a new protocol allowed respiratory care practitioners (RCP) to not begin or to discontinue BDT without indications. Our study objective was to evaluate the success of this change with emphasis on quality care and cost savings. **Methods:** All non-ventilated patients with BDT ordered were assessed by a RCP. BDT was given to patients with documented COPD; wheezing on auscultation; airways obstruction, by PFT; or other indication of airways obstruction (e.g., forced expiratory time > 4 sec). If the RCP determined that the patient did not meet criteria, the physician was notified and therapy discontinued or not started. BDT could be given to "non-indicated" patients if the attending physician directly reordered it. Formal assessments were performed with the first treatment order. Patients receiving therapy were reassessed every 72 hr and informally each treatment. We studied the 4-week period following the protocol change. The number of BDT orders not started, the number of physicians requesting "nonindicated" therapy be restarted, and the number of days on therapy were documented. Prior to initiation, the protocol was approval by the multidisciplinary Respiratory Care Advisory Council, chairs of affected departments, and the hospital executive committee. The protocol and it's goals were explained to all physicians and nurses. **Results:** Following protocol change, 100% of the BDT was indicated. Annual department savings are projected at $112,050 [calculation: annual reduced volume x (BDT direct labor + fringe benefit + equipment expense)]. The reduction in patient charges is ≈$1,102,500. Prior to program changes, the average length of therapy was 5.8 days. After protocol change, the average length decreased to 5.5 days. The significance and validity of this trend in duration is inconclusive, due to the short post-implementation review period; however, it is expected that length on therapy will be reduced. Quality of care was maintained as evidenced by: 1) all patients receiving BDT had indications, 2) no discontinued patients were restarted, 3) no attending physicians reordered BDT, and 4) of the 150 new BDT orders, 10% were not started. **Conclusions:** A protocol allowing RCPs to determine BDT administration can reduce costs and provide considerable annual savings in charges, without decreasing quality. The program has been well accepted by the medical staff, RCPs and patients.

OF-93-098

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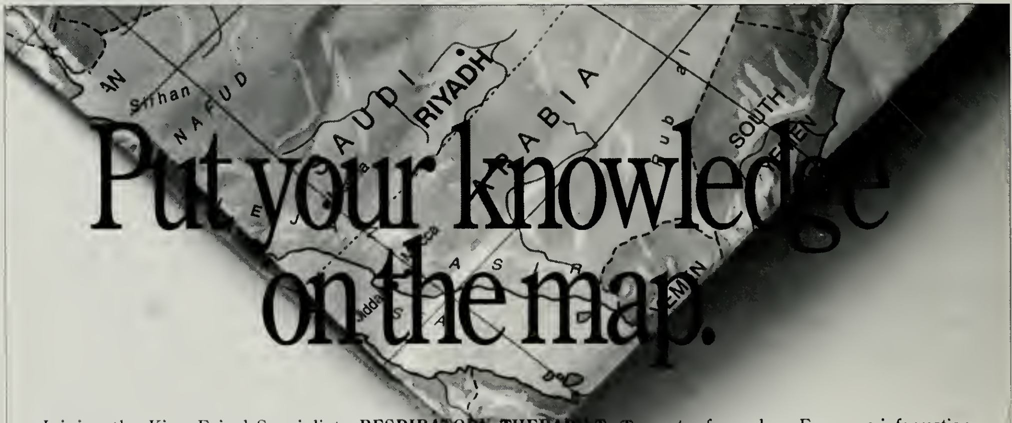

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IMPACT OF A RESPIRATORY THERAPY CONSULT SERVICE ON INAPPROPRIATENESS OF ORDERS FOR RESPIRATORY CARE.

Haney D, Orens D, Kester L, Stoller JK. Section of the Respiratory Therapy, Cleveland Clinic Foundation, Cleveland, OH.

Although the main purpose of evaluate-and-treat programs for respiratory care (RC) is to prevent misallocation, little attention has been given to whether such programs actually improve the appropriateness of ordering RC services. To address this issue, the current study compares the rate of inappropriate orders for RC services using the Cleveland Clinic Foundation Respiratory Therapy Consult Service (RTCS) vs. traditional physician-directed RC. The RTCS has been available on all adult, non-ICU inpatient wards of the Cleveland Clinic Hospital since July, 1992 and provides therapist-directed RC using sign/symptom-based algorithms. As part of a larger prospective comparison of physician-directed vs. RTCS care, the RC plans for the first 48 patients (pts) evaluated (32 RTCS pts, 16 non-RTCS pts) were assessed. Although some physicians were aware of the RC algorithms, care plans for the non-RTCS pts were physician-directed without therapist input. Appropriateness of ordering was determined by comparing the actual care plan to that generated by a study investigator, who created an algorithm-based care plan without knowledge of the actual plan. Treatments were considered inappropriate if they did not meet indicated criteria. The RTCS pts showed a trend toward more severe respiratory illness with a lower Triage Score [3.3 ± 1.1 (S.D.) vs. 4.0 ± 0.89 (S.D.), p = 0.042]. The RTCS pts also received significantly more adjustments in RC treatments after 24 hrs of hospitalization [2.03 ± 1.4 vs. 0.088 ± 1.4, p = 0.007]. Despite having a trend toward more total respiratory treatments per pt than non-RTCS pts [42.4 ± 31.8 vs. 34.6 ± 26.8, p = 0.39], RTCS pts had fewer inappropriate RC orders than non-RTCS pts [9.9% ± 15.6% vs. 50.0% ± 35.7%, p = 0.001]. We conclude: 1. The frequency of inappropriate orders for respiratory treatments in physician-directed respiratory care remains high (50%) in the current study. 2. Despite caring for patients with lower Triage Scores and longer lengths of stay, care by the Respiratory Therapy Consult Service was associated with fewer inappropriate respiratory care orders.

OF-93-100

CLINICAL PRODUCT LINE TEAMS IMPROVES PRODUCTIVITY, DECREASES OVERTIME AND ENHANCES EMPLOYEE SATISFACTION.

Susan Rinaldo-Gallo, MEd, RRT Duke University Medical Center, Durham, NC; Janice J. Thalman, BS, RRT Duke University Medical Center, Durham, NC

The Respiratory Care Services at Duke University Medical Center reorganized into three clinical teams (Medicine, Pediatric, and Surgery) in July of 1989. This was done to facilitate accountability in work distribution, scheduling and performance evaluations. Each team's table of organization consisted of designated practitioners, supervisors and a team manager which provided specialized care to three distinct patient populations. **Method:** Data was compared from April and May of 1989 and April and May of 1993. Payroll hours and productivity statistics were analyzed. Additionally, an opinion survey was completed by current staff members employed prior to the team reorganization. **Result:**

Comparative Data From 1989 And 1993:

	1989	1993
* Total Hours Worked	7,442.4	8,449.5
* Overtime Hours	718.9	470.8
* Hours Paid Not Worked	683.7	736.8
Total FTEs	93.0	105.6
Total Relative Value Units Per Day	267.4	427.3
**Productivity Factor	2.9	4.0

* Per Two Week Period

** RVUs per day divided by total FTEs

Practitioner Survey Results:

50% or More Indicated Great Improvement in:
1. Monthly schedule
2. Work assignments
3. Physician, Nursing and other healthcare worker rapport

50% or More Indicated Improvement in:
1. Department communications
2. Performance appraisals
3. Education
4. Department involvement
5. Knowledge of expectations
6. Clinical expertise
7. Advancement

The area addressed most frequently as a drawback to the team reorganization was lack of exposure and skill development with all respiratory care procedures. **Conclusions:** Department restructuring into product line teams resulted in increased productivity. In addition, overtime hours were decreased by 248.1 hours per pay period and staff noted great improvement in integral areas of operations.

OF-93-115

PRELIMINARY RESULTS OF IMPLEMENTING PATIENT DRIVEN PROTOCOLS

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UCSD Medical Center, San Diego, California.

Introduction: UCSD Medical Center is a 420 bed academic facility with a respiratory care department of 55 FTEs. In an effort to reduce the provision of unnecessary care, patient driven protocols (PDPs), defined as "patient care plans which are initiated and implemented by credentialed respiratory care practitioners" were developed. We sought to determine the early impact of PDPs on department cost. Methods: Our analysis was limited to the pulmonary floor in which 10-15% of all respiratory care is provided and the area selected to initiate the PDP program. Data was available for a 2 month period prior to the implementation of PDPs and used to determine the number of CPTs and Bronchodilator treatments (BD) received per patient (Rx/pt). Like data was collected for a 90 day period after the implementation of CPT PDPs and a 30 day period after the implementation BD protocols. CPT data was segregated for cystic fibrosis and non CF patients. Cost associated with PDP evaluations and alternative therapies was also considered. Results: We found the number of CPTs provided to CF patients decreased from 50.9 to 22.0 Rx/pt, and for non CF patients CPTs from 8.56 to 2.66 Rx/pt. Considering the reduction CPT Rx/pt and the direct variable cost of performing PDP activity the net cost reduction estimate for CPT service for this 90 day period was $5,289/month. For BD protocol patients, the number of BD treatments provided to patients decreased from 36.8 to 13.16 Rx/pt. The net cost reduction estimate for BD service for this 30 day period was $4,927/month. Discussion: Although the PDP program data is limited to two services on a single floor over a short period of time, the decrease in service demand is significant as treatments per patient were reduced, therapy was deferred, or an alternative therapy was provided. This reduction in demand provides the opportunity for a like reduction in variable supply and labor cost . Our experience demonstrated a potential cost reduction of $10,216/month or $122,592/year for two services on a single nursing unit.

OF-93-173

INPATIENT OXYGEN THERAPY: PATIENT PERCEPTIONS AND EFFECTIVENESS OF ADMINISTRATION. J.T. Kosterman, RRT, M.L. Peters, G.W. Miller, J.A. Milberg, MPH, D.J. Pierson, MD, Harborview Medical Center, Seattle, WA. O_2 therapy can be lifesaving, and its misuse in acutely ill pts can have life-threatening consequences. Nevertheless, O_2 is ordered and administered to hospitalized pts less precisely than other medications (Am. J. Med., 1992; 92:591). To clarify why this may occur, we prospectively studied the prescription and actual usage of O_2 in non-ICU medicine pts in a county teaching hospital, and also examined the pts' knowledge and attitude about O_2 therapy. METHODS: In our hospital, RC provides the wards with O_2 equipment and supplies; once O_2 is ordered, set-up and pt instruction are done by the pt's nurse. We studied every pt for whom O_2 was set up during May, 1993, administered a structured pt questionnaire on hospital day 2, and checked the pt twice a day for 2 days for O_2 set-up, actual use, and pulse oximetry. RESULTS: 122 pts entered the study; we report here data from the first 77 completed pts. 64 (83%) responded to at least 1 question regarding O_2 importance or use; 13 would/could not. 45 (74%) said the O_2 made them feel better. 43 (66%) could give a reason why O_2 was prescribed; 23 (36%) said they had received instruction on O_2 use since admission and 15 (23%) knew the liter flow. 15 pts (25% said they were supposed to use the O_2 "only when I need it," and 13 (22%) did not know when they were to use it. Compared to the other medications they were receiving, 41 (72%) said the O_2 was "very" important, 5 "somewhat" and 11 "not very" important. 258 O_2 checks on the 77 pts; 19 (24%) were wearing their O_2 every time; in 29 (38%) it was off at least once, and 29 (38%) were never found with O_2 on. The O_2 gauge was found turned off in 19 pts (24%). SpO_2 ranged from 74% to 100% and was lowest in pts not wearing O_2. 83% of pts had activity orders permitting them to be out of bed, but an extension or portable device was present in only 8%. Whether pts used their O_2 did not correlate with feeling better, knowing the reason for therapy, or remembering having been instructed in O_2 use. Pts who thought O_2 was "very important" tended to wear it more often than pts who thought it "not very important" (but $P>.10$). CONCLUSIONS: O_2 therapy for non-ICU medicine pts is often given ineffectively, and pts show poor understanding of its use. This study demonstrates a need for better pt and staff education, and supports an expended role for respiratory care practitioners in non-ICU O_2 therapy.

OF-93-178

INSTRUCTIONAL TIME FOR RESPIRATORY CARE PROCEDURES IN SCHOOLS OF NURSING

Michael J. Mahlmeister, MS, RRT, RCP
U. of California- San Francisco

A growing number of hospitals are pursuing transfer of respiratory care services to nursing staff as a cost-containment strategy. A survey was conducted to quantify current instructional time in respiratory care procedures in Schools of Nursing. **Methods:** A survey was sent to all 91 California Schools of Nursing. The voluntary survey asked the school to identify the number of hours in their curriculum specifically devoted to classroom and lab instruction (not clinical) for a variety of respiratory care procedures. **Results:** A total of 51% (47/91) schools returned the survey. Data below is compared with 6 California Respiratory Care Programs.

	RN-Mean	RN-Median	RCP Mean
O2 therapy			
Lecture	1.8	1.0 (n=12)	14.4 hrs.
Lab	1.4	0.0 (n=8)	12.2
Pulse Ox.			
Lecture	0.8	.25 (n=7)	3.0
Lab	0.2	0.0 (n=21)	1.6
ICS			
Lecture	0.5	0.0 (n=10)	2.4
Lab	0.3	0.0 (n=16)	2.8
Mech. Ventilation			
Lecture	1.1	2.0 (n=7)	80.0
Lab	0.6	0.0 (n=20)	60.0
SVN Therapy			
Lecture	0.4	0.0 (n=13)	4.6
Lab	0.2	0.0 (n=21)	3.0
MDI Therapy			
Lecture	0.4	0.0 (n=12)	3.3
Lab	0.1	0.0 (n=20)	2.4

Conclusions: These results demonstrate that graduate nurses enter the hospital with little formal training in several respiratory care procedures for which they may be asked to assume responsibility. It is important that RCPs serve as resources within hospitals, participating in staff development programs to insure that nursing staff receive adequate, appropriate training in respiratory care. A collaborative environment will help foster a setting where nurses are trained to render safe, effective respiratory care to patients.

OF-93-181

PROTOCOL IMPLEMENTATION BY RESPIRATORY CARE PRACTITIONERS IN A CARDIOTHORACIC SURGICAL ICU.

Michael P. Larkin, RRT, Diane Mendicino, Sally Smales, RRT, Anthony Liscotti, Raymond Tuttle, RRT, Morris Bierman, MD. **Univ Pittsburgh Med Center, Pittsburgh,PA.**

INTRODUCTION. The management of patients receiving mechanical ventilation (MV) usually requires the involvement of multiple individuals (e.g., respiratory therapists, physicians and nurses).This may lead to inefficient care of these patients.**METHODS.** The study was performed in a 14 bed cardiothoracic surgical ICU.Patients consisted of those having routine cardiac surgery as well as those undergoing heart or lung transplantation. A core team of 12 respiratory therapists was organized to staff the unit on a regular basis and implement the protocols.Protocols were written for weaning of supplemental oxygen and weaning from MV. Each protocol details specific manipulations of the ventilator based on clinical parameters and specific tests (pulse oximetry and arterial blood gas analysis {ABG}).Data were collected prospectively during two periods of 30 days duration.The first occurred just prior to the initiation of the protocols(Group I) and the second occurred nine months later (Group II).Data consisted of number of patients (n),length of stay in the ICU (LOS),duration of MV (MV days) and number of ABG analyses.They are presented as the Mean ± standard deviation. Comparisons were made using a t-test with statistical significance defined as $p < 0.05$. **RESULTS.**

	GROUP I	GROUP II	p
n	81	56	
LOS	5.9±9.7	5.5±7.3	0.767
MV Days	3.7±7.2	3.9±7.2	0.869
ABG	30.9±44.1	13.6±17.4	0.002

CONCLUSIONS. Protocol care resulted in a significant reduction in the use of ABG analyses.This translated into an annual cost savings of $52,372 at our institution.The duration of MV and LOS were not affected due to aspects of practice not impacted by the protocols. Enhanced participation in patient management subjectively improved RT staff morale.

OF-93-184

CROSS TRAINING NEW ROLES FOR RT'S; Joy Hargett BS RRT, Doretha Mitchell RRT, Linda Ross RRT, Bob Tippett RRT, John Sabo RRT, Wadie Williams RRT, St. Luke's Episcopal Hospital, Houston, Texas

Our non-trauma, acute care emergency department (ED) with a significant number of cardiac patients was experiencing a delay in completion of certain procedures such as ECG's, phlebotomy, and Respiratory Care treatments. Respiratory therapists (RT's) and ECG technicians were assigned to the ED on an on-call basis due to limited workloads in the area. ECG performance time was approximated at 20 minutes after order received, even for "stat" procedures. Physicians requested that ECG's be performed within 5 minutes after ordering. A massive educational program was implemented that cross trained respiratory therapists to perform ECG's and phlebotomy. After the training program, RT's were assigned to the ED on a 24 hour basis. A Continous Quality Improvement (CQI) program was developed to measure EKG performance time. A review of 560 ECG's was made. The following information was obtained: # of EKG's performed within 5 minutes after order received = 474 (84.64%), within 6-8 minutes = 45 (8.04%), > 8 minutes 41 (7.32%). Conclusions: By performing ECG's in a more timely manner, physician satisfaction is increased as well as institution of more timely treatment plans. By assigning RT's to the ED they are more readily available for other acute situations such as intubation and cardiac arrests. Currently we are investigating other critical roles for RT's in the ED setting, such as blood analysis, IV starts, etc.) to increase productive time. Role expansion should include those critical tasks that enhance patient outcome and increase role responsibility of the therapist.

OF-93-189

AARC Videoconferences

Tuberculosis In the Era of HIV: The Implications for Patients and Practitioners

February 1: 12:30 p.m. to 2:00 p.m. Eastern Time (One CE Credit)

After years of decline, the incidence of tuberculosis is now on the rise, which is further complicated by the HIV epidemic. This session reviews the reasons for this change and the implications for patients and practitioners. Dr. Iseman will discuss the medication-resistant TB, Universal Precautions for patients and practitioners, emergency room procedures, treatment procedures, and new medications.

1994 Professor's Rounds in Respiratory Care
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Therapist-Driven Protocols: Implementation

March 29: 12:30 p.m. to 2:00 p.m. Eastern Time (One CE Credit)

Get answers to your questions about how to implement a therapist-driven protocol (TDP) with this program. Learn how to implement a TDP, what research should be performed prior to initiating; how to select staff to perform within the protocol arena; and what additional training should be addressed. Dr. Stoller will also provide a summary of the results of therapist-driven protocols and address the obstacles that stand between the desire to have protocols and their implementation. The session will present a special focus on the attitudes of physicians, top management, and nurses regarding TDPs.

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AARC Videoconferences

New Strategies for Asthma Management

May 11: 12:30 p.m. to 2:00 p.m. Eastern Time (One CE Credit)

This program discusses asthma patient education, self-management techniques, and use of a peak flow meter. Included are a discussion on the morbidity and mortality of asthma, therapy goals from the National Asthma Education Program, medication delivery devices, anticholinergics, cromolyn use, steroid controversies, and emergency room procedures.

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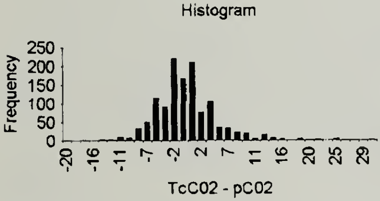
RELIABILITY OF TRANSCUTANEOUS C02 MONITORING IN A PEDIATRIC I.C.U.

R.L.Dipert RRT, NREMT-P, S.Ciarlariello BA, RRT, *K. Beal, Ph.D., *B. Mann, Ph.D., W.A. Spohn MD, R.C. Cohn MD. The Children's Medical Center, Dayton, Ohio. *Wright State University Statistical Consulting Center.

Introduction: To determine the usefulness of transcutaneous C02 monitoring (TcC0_2) in the pediatric ICU, we evaluated the reliability of TcC0_2 recordings with simultaneously obtained arterial blood gas PaC0_2's from 60 sequentially selected pediatric patients (age < 20 years). These patients presented with one or more of 42 different diagnoses. In this population, 1281 arterial blood gas samples were correlated with TcC0_2 readings All patients were on a Sensormedics Transend or FasTrac monitors. Transcend probe temperatures ranged from 42 to 43^0 C, with site changes every 3 - 4 hours and calibration every 4 - 6 hours, and 41^0 C for the FasTrac's with calibrations every 8 hours. All samples were run on Corning 278 analyzers. **Results:** PaC0_2's ranged from 14.6 to 80 mmHg. Of the 1281 samples reviewed, 541 (42.24%) showed the TcC0_2 reading lower than the PaC0_2, 164 (12.78%) were identical and 576 (44.97%) were higher than the measured PaC0_2. Two samples were omitted from the results due to gross inaccuracy (> +/- 40 torr deviation). We evaluated the data for a TcC02 deviation of > 6 torr below the PaC02, feeling that this would constitute a clinically significant deviation, of which only 4.9% of the readings deviated below 6 torr. 84% of the samples were within +/- 6 torr.



We conclude that continuous TcC0_2 measurement can be a useful non invasive means of monitoring in the pediatric ICU.

OF-93-015

AN ALTERNATIVE METHOD FOR DELIVERY OF RIBAVIRIN TO VENTILATED PEDIATRIC PATIENTS—

Evan A. Steinberg MD, John L. Cefaratt BS RRT, Donn Webb RCP, Lisa Demshki RCP. Kaiser Permanente, Los Angeles Medical Center, Los Angeles, California.

BACKGROUND: Despite a growing body of reassuring data, healthcare workers remain concerned about occupational exposure to ribavirin. Cal-OSHA has calculated a time-weighted average (TWA) of < 2.7 $\mu g/m^3$ as a safe level in ambient air. However, because long-term follow-up data are lacking, many people have adopted an attitude of "the lower the better." We have explored ways of minimizing drug spill into the environment when administering through a pressure-limited ventilator. **METHOD & MATERIALS:** Four aspects of medicine delivery were evaluated for their effects on levels of ribavirin in room air (1). Two infant/pediatric ventilators (Sechrist and the Bear Cub) for performance of delivery. (2). Techniques for filtration of the effluent gases (single filter, dual filter, and rotation of filters) for elimination of exhaled ribavirin. (3). Evaluation of the effects of humidification on the crystallization of ribavirin in the patient's circuit. (4). Effects of a scavenging system attached to the ambient side of the exhalation valve for elimination of exhaled ribavirin that passed through the filters. Samples were taken at 2, 6, and 12 feet from the drug source at a level of 4-5 feet above the floor. Three sets of samples were taken: a. normal circuit without filters, b. the same circuit including dual filters on the expiratory limb of the patient circuit, and c. the same circuit with the filters and with the scavenger system. Sample cassettes were identified only by random number assignments and were sent to an independent lab for analysis by liquid chromatography. **RESULTS:** Our study indicated the Sechrist performed more efficiently as compared to the Bear Cub. Dual filters with a rotation schedule of every 4 hours (removing the proximal filter and inserting a new distal filter) were effective in reducing the ambient ribavirin levels. Humidification was a vital part in the success of delivering ribavirin safely through the Sechrist to infants and pediatrics. Finally the scavenger system provided extra protection in the elimination of the exhaled gases but may not have been essential since the filters reduced the exposure levels to a range below 2.7 *ug*/m^3. Ambient air samples in the patient room indicated that the circuit without any filtration produced levels in excess of 200 *ug*/m^3, while the same circuit with filters had reduced the ambient levels to <2.3 *ug*/m^3. The scavenger system reduced ambient air levels to non-detectable. **CONCLUSION:** We recommend that the Sechrist be used for the administration of ribavirin to ventilated patients on infant/pediatric ventilators. Dual filters should be used at the distal end of the expiratory limb with a rotation schedule of every 4 hours. Mild humidity condensation is essential for reducing the risk of crystallization buildup within the patient circuit, especially at the patient wye. Finally, for added safety, a scavenger system on the ambient side of the exhalation valve could be incorporated for further reduction of exposure.

OF-93-055

A SURVEY OF BETA AGONIST DELIVERY IN PEDIATRICS. Daniel J. Post, BS RRT, Loyola University Medical Center, Maywood IL. Robert M Lewis, BA RRT, Children's Memorial Hospital, Chicago, IL. Some recent changes in the management of asthma include continuous albuterol nebulization (CA); higher dosages (D); and the use of peak flow monitoring (PFM). We surveyed children's hospitals (CH) and general university affiliated teaching hospitals (TH) to assess how these recommendations have affected practice. **Methods.** 111 CHs and THs were surveyed to determine who was responsible for aerosol treatment (tx) administration, the extent of PFM, and the D used with CA. **Results.** 68 (61%) of the hospitals responded, 56 provided sufficient data for analysis. 29% used PFM "always" and 48% "occasionally". CHs were more likely to use PFM than THs (96% vs 63%, $p<.01$, chi sq). Txs were the responsibility of RTs in 56% of hospitals (H), and of RTs and RNs jointly in the rest. Where only RTs did txs, PFM was done more often (90% vs 55%, $p<.05$, chi sq). The number of Hs reporting joint RT/RN responsibility for Txs in the NICU increased from 2% in a similar 1989 survey (Respir Care 34:1024, 1989) to 18% in the current survey ($p<.01$, chi sq). CA is offered in 77% of Hs responding. 35% reported Ds in mg/hr (range 3 - 50 mg/hr) (80% delivered 20 or less mg/hr.) 23% reported Ds in mg/kg/hr (range .05 - .5 mg/kg/hr). **Conclusion.** PFM is widely used, especially in CHs and Hs with RTs doing Txs. CA is widely available, but no consensus exists concerning Ds. Joint RT/RN responsibility for Txs is common and appears to be increasing.

OF-93-083

SIMULATED HELICOPTER TRANSPORT USING HIGH FREQUENCY JET VENTILATION Philip "Buc" Rogers BS, RRT, EMT-A. Jamie Taylor BS, RRT, NREMT-P. Darrell Benham BS, RRT. Robert Arrington MD.
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Background: This bench test was done to determine the compatibility, function, and time limitations of a mobile HFJV transport system suitable for helicopter transport and an adjunct/alternative to mobile extracorporeal membrane oxygenation. Methods: Testing was done with a Bunnell HFJV, an Airborne Life Support System transport isolette equipped with a Bio-Med MVP-10 pressure ventilator, and an American Power Conversions power supply (UPS) #450 AT. Air and oxygen were supplied via Medical-60 tanks integral to the transport isolette sled. Air transport was by a Sikorsky S76-A equipped with 115 VAC and an 8 liter LOX. Bench Tests were performed with HFJV settings of: 520 BPM, Paw 35 cmH$_2$O, PEEP 5 cmH$_2$o, F$_I$O2 1.0, T$_I$ 0.020s. MVP-10: 10 BPM, Paw 30 cmH$_2$O, PEEP 5 cmH$_2$O, F$_I$O2 1.0, T$_I$ .5s with a flow of 4 l/m. Flight tests were performed at 400 (helipad), 2000, 5000, 8000 ft., and during autorotation descent from 8000 to 1000 ft. Conclusions: Medical-60 tanks powered the HFJV for two hours and the UPS provided 30 minutes of alternate power, thus providing ample time to transfer from hospital to helicopter. Flight tests showed no interference with the HFJV by rotor vibration, motion or communication equipment. An increase of 1 cmH$_2$O PEEP was experienced at 5000 ft. due to decrease in the barometric pressure at that altitude. No interference in avionics from the HFJV was noted.

OF-93-092

CURRENT STATUS OF HIGH FREQUENCY VENTILATION: REPORT FROM THE INTERNATIONAL HFV REGISTRY.

JM Asselin, DJ Durand, et al. *Children's Hospital Oakland, Ca.*

Although high frequency ventilation (HFV) is widely used to treat infants with lung disease, there are only three large published studies of HFV. Each of these studies evaluated a different device, and none of them evaluated the role of HFV in the post-surfactant era. Most of the data now in print about the use of HFV in neonates comes from small studies, and probably does not represent current clinical use of HFV. We developed an international registry of patients treated with HFV to learn how each of the three major HFV devices is currently used, and to determine the outcome of infants treated with each of these HFV devices. 54 hospitals that used the SensorMedics 3100/3100A HFOV, the Bunnell Life Pulse HFJV, and or the InfantStar HFV contributed data to our registry. A total of 517 neonates were treated between July 1, 1992 and December 31, 1992. The median number of patients treated at each center during the study period was 6 (range 1-46).

	SensorMedics	Bunnell	Star
Number	298	130	89
BW(gms)	1928±1119	1826±1152	1223±903
Indication for HFV			
Unabl Oxy	58%	50%	52%
UnablVent	24%	44%	45%
PrevPIE	20%	9%	10%
PrevAL	13%	13%	2%
Trt PIE	17%	28%	44%
Trt AL	11%	16%	26%
28d Surv	77%	60%	56%
Outcome for survivors			
Days HFV	5.2±6.4	4.7±7.5	5.3±7.7
Age Ext	18.6±20.2	23.6±23.8	22.7±17.1
Age RA	23.3±25.1	28.9±30.7	28.2±22.9
ICH Wrs	1%	2%	5%
ICH New	10%	8%	10%

Survivors were treated significantly earlier than were non-survivors. In survivors, OI improved within the first 4-6 hours of HFV, as opposed to non-survivors. There were no significant differences between devices in the rate of development or worsening of ICH. The lower incidence of survival in the Star patients may be due to their lower weight.

OF-93-101

HIGH FREQUENCY OSCILLATORY VENTILATION AS A RESCUE TECHNIQUE FOR PEDIATRIC PATIENTS WITH RESPIRATORY FAILURE: MULTI-CENTER EXPERIENCE.

DJ Durand MD, JM Asselin BA RRT, J Hanson MD, R Clark MD, T Bachman. From the Division of Neonatology, Department of Respiratory Care, Division of Intensive Care, Children Hospital Oakland; Division of Neonatology, Emory University; Crane Consulting.

Although high frequency oscillatory ventilation (HFOV) has been well studied in neonates, there is minimal data available about its use in pediatric patients with severe respiratory failure. We surveyed all centers which had purchased a SensorMedics 3100 to determine their experience with HFOV in the pediatric population. 40 of the 66 patients treated with HFOV survived (61%). The mean duration of HFOV treatment was 9.8 days (range < 1 day to 125 days). Survivors and non-survivors were similar prior to the initiation of HFOV, except that the survivors were slightly younger than the non-survivors ($P=0.04$). After 24 hours, the survivors had significantly better P_aO_2/P_AO_2 ratio ($P < 0.01$) and oxygenation index ($P < 0.001$) than prior to HFOV, while there was no improvement in P_aO_2/P_AO_2 ratio or OI in the non-survivors. There was a significant difference in mean airway pressure between the survivors and non-survivors after 24 hours of HFOV. For the survivors, mean airway pressure had gone from 22.9 ± 6.4 cm H_2O prior to HFOV to 25.4 ± 6.1 cm H_2O after 24 hours of HFOV (P = NS), compared to an increase in the non-survivors from 23.7 ± 8.6 cm H_2O prior to HFOV to 33.4 ± 7.2 cm H_2O after 24 hours of HFOV ($P < 0.005$). There was a significant difference in the survival of patients, depending on when HFOV was begun. Of the patients started on HFOV after less than 10 days of conventional ventilation 97% (31/39) survived, compared to only 33% (6/18) of the patients who were begun on HFOV after 10 days of conventional ventilation. This is despite the fact that there was no difference in the mean age, ventilator settings, or arterial blood gases of the two groups prior to HFOV. Studies of pediatric patients with ARDS and severe respiratory failure show the mortality rate varying from 60-75%. Data reported in this study suggests HFOV may be both safe and effective in improving the outcome of these critically ill children. ECMO is also a therapy often used in similar patients. The national ECMO registry reports an overall survival of 50% in pediatric patients managed with ECMO. Survival in this study is similar.

OF-93-102

CARDIAC TAMPONADE VS HYPOVOLEMIA ON VENO - ARTERIAL EXTRACORPOREAL LIFE SUPPORT

DR Hansell,RRT; JR Kirchoff,RRT; BG Wilson,RRT; RA Leonard,RRT, JN Meliones,MD; Duke Childrens Hospital, Durham, NC

Baby Boy N was on day 3 of VA ECLS cannulated via a transthoracic approach for PPHN. All vital signs and laboratory values were within normal limits. Despite no alterations in the pump flow (100 ml/kg/min), at hour 36 a prolonged & steady increase in the SvO_2 (10-15 % over 2-3 hours) was noted. Blood pressure & Mean Arterial Pressure (MAP) were elevated (MAP increase of 10 - 15 torr) while heart rate was unchanged. Pulse pressure decreased to zero & patient ABG values closely approximated circuit ABG values. Cardiac tamponade was suspected & the mediastinal chest tube was "stripped" and 60 ml of blood evacuated. Patient ABG, SvO_2, blood pressure & MAP returned to baseline with a pulse pressure of 8-12 torr.

24 hours later a prolonged & steady increase in the SvO_2 (increase of 10-15%)was again noted. Blood pressure & MAP were decreased by 10-15 torr while the heart rate increased. Venous reservoir pressures were decreased by 10-20 torr. Pulse pressure decreased to near zero & patient ABG values closely approximated circuit ABG values. Cardiac tamponade was suspected; however, the mediastinal tube had no additional drainage when stripped. 20 ml of 5% Albumin was infused as a volume expander. Patient ABG, SvO_2, blood pressure & MAP returned to baseline with a pulse pressure of 8-12 torr.

Cardiac tamponade is a life threatening event which requires prompt diagnosis & intervention. Tamponade is more frequently observed in the transthoracically cannulated patient though it can occur in neck cannulation. Because VA ECLS maintains cardiac output vital signs may be only slightly altered despite significant tamponade. Undetected tamponade may limit coronary blood flow injuring the myocardium. Differential diagnosis between tamponade & hypovolemia is essential & is outlined below. One should maintain a high index of suspicion for tamponade in patients cannulated transthoracically since tamponade, though life threatening, is reversable.

	PaO_2	Venous Return	Pulse Press	SvO_2	Heart Rate
Tamponade	↑	no change	↓	↑	dysrhythmia
Hypovolemia	↑	↓	↓	↑	↑

OF-93-113

HIGH FREQUENCY OSCILLATORY VENTILATION AS A BRIDGE OFF ECMO FOR REFRACTORY HYPERCAPNEA IN PEDIATRIC RESPIRATORY FAILURE-M.J.

Heulitt, M.D., M.Binns, B.A. R.R.T., M. Anders, B.S. R.R.T., A. Torres, Jr., M.D., Arkansas Children's Hospital, Little Rock AR.

Risk of complications such as bleeding and sepsis for patients on pediatric ECMO increase with the length of the ECMO course. In order to shorten the ECMO course the patient must be able to be weaned to a mode of ventilation that supports the patient with adequate gas exchange without exposing them to high airway pressures or inspired oxygen. In the situation where oxygenation is adequate but hypercapnea limits the ability to wean to conventional ventilation (CV), high frequency oscillatory ventilation (HFOV) is an alternative.

Case Summary: a 2 y.o. female was transferred to our facility with ARDS after being involved in a MPA. After nine days of CV the patient developed decreasing PaO_2/F_IO_2 ratio and hypercapnea on maximal settings, the patient was placed on veno-arterial ECMO. The ECMO course was complicated by excessive bleeding. Three successive trials off ECMO on CV (pressure control PIP= 40/PEEP 6, f=40) failed due to hypercapnea. $PaCO_2$'s during attempted trials off ECMO on CV were 77, 81, and 90 torr respectively. A fourth trial off ECMO utilizing HFOV (amplitude 70 cmH20, 8 hertz, Mean Paw 28, Ti% 33, $Fi0_2$ .60) was successful with a $PaCO_2$ of 47 torr. The patient was decannulated within two hours of being placed on HFOV(ECMO hour 455). HFOV was utilized for 24 days, with settings ranging from amplitude 42-80 cmH_20, 7-8 hertz, Mean Paw 15-30,Ti%30, $Fi0_2$ .50-.60) The patient was subsequently weaned to CV on ventilation day 51 and extubated on ventilation day 70 . She has been subsequently discharged from the hospital and was seen in follow-up clinic with normal neurologic and pulmonary function.

Conclusion: HFOV as a bridge off ECMO should be considered in the case of refractory hypercapnea in the pediatric patient with ARDS.

OF-93-146

DELIVERY OF RIBAVIRIN IN CONJUNCTION WITH HIGH FREQUENCY JET VENTILATION (HFJV)-CASE REPORT.

Dena Vallieu, CRTT; Herbert Patrick, MD; Alan Spitzer, MD; Harry Sachs, MD.;Stephen Baumgart, MD;
Thomas Jefferson University Hospital, Philadelphia, PA

A 2-month old infant (GA 32-weeks) presented with rapidly progressive bronchopneumonia secondary to respiratory syncytial virus (RSV). RIBAVIRIN was administered via conventional mandatory ventilation (CMV) at 45 bpm, PIP of 35 cm H_20 and F_IO_2 1.0, without response. At 12 hr. HFJV was instituted and advanced to PIP 42 cm H_2O, rate 420 bpm, F_IO_2 1.0. RSV was persistently recovered from nasal secretions. RIBAVIRIN was re-administered via Conventional Circuit (CC) at the humidifiers water port. A one-way valve for RIBAVIRIN was introduced upstream from the humidifier's temperature monitor probe. Filters on the conventional ventilator's exhalation gas outlets were changed every 1-2 hours. During a 10 hr RIBAVIRIN course, the CC sigh breaths delivered RIBAVIRIN into the HFJV-Hi/Low endotracheal tube as evidenced by precipitation observed in the hub of this appliance. As the humidifier's dual-heated wire temperature was increased from 35 to 37°C, precipitation was not sufficient to interrupt mechanical ventilation by either conventional or HFJV appliances. We encountered no complications of this therapy, however, the infant proceeded onto extra corporeal membrane oxygenation (ECMO) after one day on HFJV. RIBAVIRIN was continued uninterrupted during ECMO by CC. Delivery of RIBAVIRIN may be accomplished during HFJV without interruption of therapy or precipitous complications.

OF-93-179

FIO2 CHANGES DURING MDI ACTUATION IN THE INFANT TEST LUNG. Valerie Whyte RRT, RCP, Tom Malinowski BS,RRT, RCP, Gerry Ellis, MBA, RRT, RCP, Ronald Perkin, MD. Department of Respiratory Care, Loma Linda University Medical Center, Loma Linda, Ca.

Introduction: The use of MDI in intubated infants with tida volumes of less than 100 ml is not recommended due to potential hypoxic gas mixtures (AARC Aerosol Consensus Statement, Resp. Care 1991:36; 919). We measured the amount of change (AOC) in FIO2 during MDI actuation at varying intervals, the length of time to recover (TTR) to baseline, and the effect of lung compliance (CL) during ventilation of an infant lung model. **Method:** The test lung was ventilated with a pediatric Laerdal hand resuscitator via 3.0 mm endotracheal tube at a rate of 25 using Ppk of 25 cm H2O, at 21%, 40% and 60% FIO2. CL was set at 3 ml/cm H20. At each FIO2, the MDI was actuated into a spacer without interrupting ventilation at 30, 15, 10 and 5 second intervals over a 3 minute period. Test CL was set at 3, 1 and 10 ml/cm H20 to measure the effect on TTR. **Results:**

Lowest Measured FIO2 at Actuation Intervals*

Baseline	30 sec.	15 sec.	10 sec.	5 sec.
21%	20 ± 0	20 ± 0	19.4 ± .5	18.8 ± .6
40%	38 ± 0	37.5 ± .5	37.4 ± .5	36 ± .8
60%	56.5 ± .5	56.3 ± .5	56.9 ± .3	57 ± 0

*mean ± standard deviation (sd)

TTR at Actuation Intervals (seconds)*

Baseline	30 sec.	15 sec.	10 sec.	5 sec.
21%	4.1 ± 1.7	7.9 ± 1.9	11.3 ±2.5	20 ± 3.2
40%	8.8 ± 6.4	9.3 ± 1.4	13.6 ±5.4	19.6 ± 4.2
60%	12.5 ±2.2	11.1 ±4.5	17 ± 2.8	25.8 ± 7.2

*mean ± sd

Effects of CL on TTR (seconds)*

CL **	TTR mean	SD	P value
3	12.5	± 2.195	na
1	30.66	± 7.475	> .005
10	8.25	± 1.956	> .005

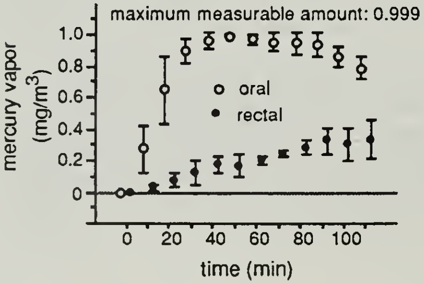
*at 60% FIO2 **ml/cm H20

Conclusion: 1) FIO2 decreased for all levels of FIO2 (range: 1-4%). We postulate that infants sensitive to small reductions in FIO2 may require increased FIO2 during MDI. 2) Recovery to baseline FIO2 was achieved only at actuation rates >10 seconds. 3) Higher compliance values reduce TTR, probably due to larger delivered VT. 4) Further studies need to be performed before MDI can be recommended for infants ventilated with VT <100ml.

OF-93-183

MERCURY CONTAMINATION OF INFANT INCUBATORS David L. Potts, RRT, Igor Grahovac, BS, Robert L. Chatburn, RRT; Rainbow Babies & Childrens Hospital, Cleveland, OH.

INTRODUCTION: The purpose of this study was to determine if thermometer breakage in incubators can produce toxic levels of mercury vapor (MV). The OSHA (Occupational Safety and Health Administration) standard for adult exposure to mercury vapor is a time weighted (8 hr) average concentration of 0.05 mg/m^3. **METHODS:** An Ohmeda Care Plus Incubator was readied for use on an infant and a baseline MV level was obtained using a Jerome 431-X Mercury Vapor Analyzer. Oral and rectal thermometers were then broken in the incubator (two experiments for each type) and their contents allowed to pool at the back of the base platform, to the rear of the fan blade. The incubator was kept at room temperature (22-24°C). Measurements of MV concentration were made every 10 minutes for 110 minutes. Another experiment was performed with an oral thermometer at a temperature of 31.7°C (the mean temperature setting of incubators found at Rainbow Babies and Childrens Hospital). MV level readings were recorded at 10 minute intervals for a period of eight hours. **RESULTS:** Mercury vapor levels (mean ± SD) were higher for the oral vs the rectal thermometers (see Fig.). For all conditions, MV concentration remained above 0.05 mg/m^3. The 110 minute time weighed average concentration was 0.48 mg/m^3 ; the 8 hr average was 0.34 mg/m^3. **CONCLUSION:** When broken in a closed incubator, mercury filled thermometers produced MV levels that exceed the OSHA limit for an eight hour time weighted average. Since MV is a known nephrotoxin,neurotoxin, skin and pulmonary sensitizer we recommend using alternative temperature measuring devices.



OF-93-142

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at the 39th Annual Meeting and Exposition
of the
American Association for Respiratory Care

December 11-14, 1993
Nashville, Tennessee

Thousands of examples of respiratory care equipment and supplies are displayed, discussed, and demonstrated in the exhibit booths at the Annual Convention. The AARC thanks the firms that support the Association by exhibiting. (Exhibitors confirmed by October 21, 1993, are listed.)

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Saturday, December 11	12:00 noon - 4:00 pm
Sunday, December 12	11:00 am - 4:00 pm
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SPECIFICATIONS—READ CAREFULLY!

An abstract may report (1) an **original study**, (2) the **evaluation of a method or device**, or (3) a **case or case series.** Topics may be aspects of adult acute care, continuing care/ rehabilitation, perinatology/pediatrics, cardiopulmonary technology, health occupations education, or management of personnel and health-care delivery. The abstract may have been presented previously at a local or regional—but not national—meeting and should not have been published previously in a national journal. The abstract will be the only evidence by which the reviewers can decide whether the author should be invited to present a paper at the OPEN FORUM. Therefore, *the abstract must provide all important data, findings, and conclusions.* Give specific information. Do not write such general statements as "Results will be presented" or "Significance will be discussed."

Essential Content Elements

An **original study** abstract *must* include (1) Introduction: statement of research problem, question, or hypothesis; (2) Method: description of research design and conduct in sufficient detail to permit judgment of validity; (3) Results: statement of research findings with quantitative data and statistical analysis; (4) Conclusions: interpretation of the meaning of the results. A **method/device evaluation** abstract *must* include (1) Introduction: identification of the method or device and its intended function; (2) Method: description of the evaluation in sufficient detail to permit judgment of its objectivity and validity; (3) Results: findings of the evaluation; (4) Experience: summary of the author's practical experience *or* a notation of lack of experience; (5) Conclusions: interpretation of the evaluation and experience. Cost comparisons should be included where possible and appropriate. A **case report** abstract *must* report a case that is uncommon or of exceptional teaching/learning value and must include: (1) patient data case summary and (2) significance of case. Content should reflect results of literature review. The author(s) should have been actively involved in the case and a case-managing physician must be a co-author or must approve the report.

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Authors may choose to submit abstracts early. Abstracts received by March 5 will be reviewed and the authors notified by April 22. Rejected abstracts will be accompanied by a written critique that should in many cases enable authors to revise their abstracts and resubmit them by the final deadline (May 28).

Final Deadline

The mandatory Final Deadline is May 28 (postmark). Authors will be notified of acceptance or rejection by *letter only*— to be mailed by August 15.

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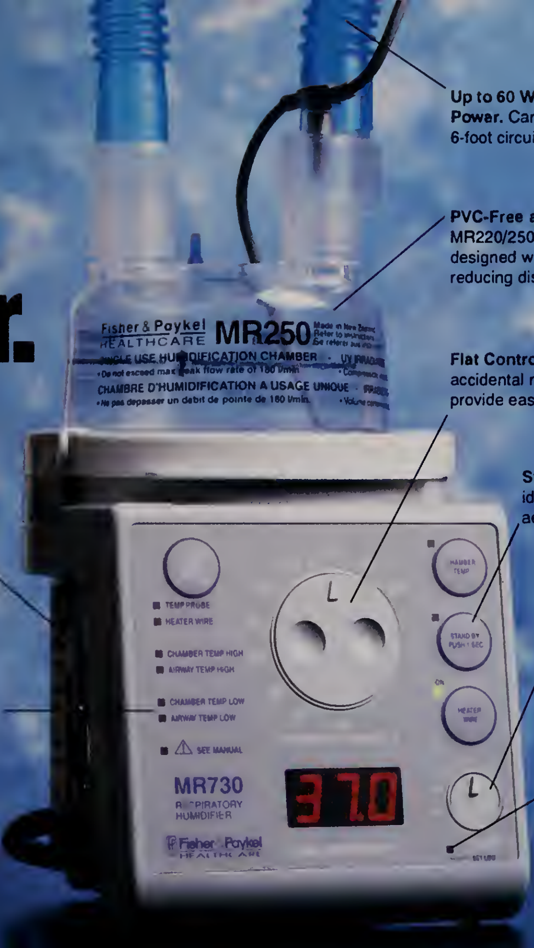

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